BULLETIN

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AND

THE PHYSICAL SOCIETY

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47 BELGRAVE SQUARE, LONDON, S.W.1. TELEPHONE: BELGRAVIA 6111

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute and Society necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute and Society for advice.

UNIVERSITY OF NATAL DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS

Applications are invited from suitably qualified persons for appointment to the post of PROFESSOR OF MATHEMATICS OR APPLIED MATHEMATICS, DURBAN. The salary attached to the post is R5,400 (£2,700) per annum, fixed. Applicants who have specialized in Pure or Applied Mathematics or in Theoretical Physics will be considered on the same basis, no one of these disciplines being given preference over the other. Applications forms, and further particulars of the post, including commencing dates, etc., are obtainable from the Secretary, Association of Universities of the British Commonwealth (Branch Office), Marlborough House, Pall Mall, London, S.W.1. Applications close, in South Africa and London, on October 31, 1961.

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

A RESEARCH ASSISTANT is required for work in connection with a laboratory investigation of the luminescence of minerals as part of a research programme concerned with the luminescence of the moon which is being undertaken in the Department of Physics. Applicants should be graduates in Physics with some research experience, preferably in the fields of particle accelerators or spectroscopy. Appointment will be for one year in the first instance, with the possibility of an extension, and starting as soon as possible, at a salary in the range £800 to £1,000 per annum. Forms of application may be obtained from the Registrar of the College, Sackville Street, Manchester, 1, to whom they should be returned as soon as possible.

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER

required by WAR OFFICE, Directorate of Civilian Medical Services, Central London. Duties—work in close co-operation with medical officer (radiation), and site and personnel monitoring. Expected to keep abreast of current developments and literature. Opportunities for applied research. Selected candidate will attend training courses. Qualifications: Pass degree or H.N.C. in Physics or Applied Physics. Good knowledge of Health Physics and/or Chemistry. Age A.E.O. 18-28. E.O. minimum age 27. Salary: A.E.O £503–£1,038 p.a. E.O. £1,147–£1,396 p.a. Opportunity for establishment and promotion. Forms from Ministry of Labour, Technical and Scientific Register (K), 28 King Street, London, S.W.1, quoting A 376/1A

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

APPOINTMENT OF ASSISTANT LECTURER IN PHYSICS

Applications are invited for an Assistant Lectureship in Physics in the College with the title and status of Assistant Lecturer in the University of Manchester. The successful candidate will be required to take part in the teaching of the department which is almost entirely concerned with internal degrees of the Faculty in Physics and other subjects. He will also be allowed ample time for research under the general direction of Professor H. Lipson, the main subjects at present being X-ray diffraction, physical optics, acoustics and luminescence. Salary in the scale £800 × £50 – £950. Superannuation under the F.S.S.U. Family allowances. Conditions of appointment and forms of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester 1, to whom applications must be returned by Saturday, November 4, 1961.

THE ROYAL UNIVERSITY OF MALTA

Applications are invited for the Chair of Physics. Salary £2,050 p.a. (including overseas allowance). F.S.S.U. Passages provided for appointee, wife and children under 12 years on appointment and normal termination. Duties to be assumed as soon as possible. Detailed applications (six copies) naming three referees as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

ST. JOHN STREET, LONDON, E.C.1

Applications are invited from scientists or engineers with good academic qualifications and appropriate research and industrial experience for the post of Senior Lecturer in Automatic Control in the Department of Production Technology and Control Engineering. The person appointed to the post will be expected to take over leadership of the work in this subject. The duties include teaching in the Courses for the Postgraduate Diploma of Northampton College and the Diploma in Technology, the development of laboratories and the supervision of research. Personal research and consultancy are encouraged. Salary on scale: £1,580 – £1,800 p.a. Prospects of upward revision. Forms and further particulars from Secretary. It is desired to make the appointment at the earliest opportunity.

BUILDING RESEARCH STATION

(D.S.I.R.), Garston, near Watford, Herts., requires Physicist as Scientific/Senior Scientific Officer for work on problems of air movement, stratification and mixing processes basic to an understanding of ventilation in buildings. The movement of air is one of the classical topics of building physics. Qualifications 1st or 2nd Class Honours Degree in Physics. For S.S.O. post minimum age 26, and at least three years postgraduate research experience in field of aerodynamics, fluid flow or meteorology. Interim salary ranges S.O. £717–£1,222. S.S.O. £1,302–£1,654. Forms from Director, above address quoting BRS 19Y. Closing date October 30, 1961.

HARRIS COLLEGE, PRESTON

PRINCIPAL: H. WILKINSON, M.Sc.Tech., Ph.D., A.Inst.P.

Owing to expansion of the work of the College, applications are invited for the following new posts: DEPARTMENT OF PHYSICS AND MATHEMATICS. 1. SENIOR LECTURER IN PHYSICS for work up to the level of the Pt. II examination of The Institute of Physics and to assist with the development of new courses in Applied Physics. 2. LECTURER IN MATHEMATICS to teach up to degree level. 3. ASSISTANT LECTURER (Grade B) in Physics with some Mathematics to teach up to the level of Grad.Inst.P. Salary scales: Senior Lecturer: £1,550 × £50–£1,750. Lecturer: £1,370 × £35–£1,550. Assistant Lecturer (Grade B): £700 × £27 10s. and final increment of £37 10s.–£1,150, with increments for training and experience. Further details and forms from the Principal, to whom applications should be returned.

W. R. Tuson, Clerk to the Harris Council.

NATIONAL PHYSICAL LABORATORY (D.S.I.R.) Teddington, Middlesex,

requires Senior Scientific Officer/S.O. to work on radiation dosimetry. Training given if necessary in existing techniques; work will extend the existing energy range of absolute dose measurement to include very high energy x or gamma radiation. Qualifications: 1st or 2nd Class Honours Degree in physics or equivalent. For S.S.O. minimum three years postgraduate research experience. Interim Salaries: Scientific Officer—£773–£1,267, Senior Scientific Officer–£1,392–£1,714. Posts unestablished with possibility of establishment through the Civil Service Commission whilst remaining under 32. Forms from Director, above address quoting NPL.682Y. Closing date November 30, 1961.

SPACE RESEARCH

Two Physicists (men or women) required as Experimental Officers (minimum age 26) for the Royal Aircraft Establishment's Space Research programme at (*a*) Aberporth, Cardiganshire and (*b*) Bramshott, Nr. Farnborough, Hants. Qualifications: Pass degree, H.N.C., Grad.Inst.P. or equivalent. Applicants must be experienced in handling and use of precision mechanical instruments; have interest in astronomy, and ability to deal with simple electrical and electronic equipment. Work involves irregular hours and observations at any hour of night. The officers appointed will organize and carry out, with assistance, routine observations of artificial satellites with high precision photogrammetric equipment including harmonization of observations with Universal Time to high accuracy. In addition, at Bramshott, they will assist in research and development of appropriate photogrammetric methods. Salary Range: £1,087–£1,336. Write to Mr. M. J. Lighthill, F.R.S., Director, R.A.E., Farnborough, Hants., quoting reference M.O.A. HC/2D/714.

ENGINEERS, PHYSICISTS and MATHEMATICIANS required by Ministry of Aviation at ROYAL RADAR ESTABLISHMENT, Malvern, Worcs. for work on FUTURE INTEGRATED MILITARY/CIVIL AIR TRAFFIC CONTROL SYSTEMS. Work includes system studies by analysis and simulation; radar engineering, automatic data processing and transmission with opportunity to specialize in digital electronics, computer design, scientific programming and display techniques. Appointments in grade of (i) Senior Scientific Officer; (ii) Scientific Officer; (iii) Experimental Officer. Qualifications: (i) and (ii) Degree or Dip.Tech. with 1st or 2nd class honours or equivalent qualification and, for S.S.O. (minimum age 26) at least 3 years postgraduate research experience; (iii) (minimum age 26) Pass degree, H.N.C. or equivalent. Salary scales (i) £1,342–£1,654; (ii) £738–£1,222 with F.S.S.U. benefits; (iii) £1,087–£1,336. Opportunity for candidates under 31 (normally) to compete for established (non-contributory pensionable) posts. Details and application forms obtainable from Dr. W. H. Penley, C.B.E., R.R.E. Malvern, Worcs. (quoting HC/2D/0751).

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(University of Reading)

Applications are invited from Honours Graduates in Physics to take part in a programme of work concerning the physical properties of milk. Preference will be given to candidates who have had appropriate research experience. Salary within range of £1342-£1654 with F.S.S.U. pension provision. Applications, naming two referees, to the Secretary, N.I.R.D., Shinfield, Reading. Quote reference 61/27.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

SCIENTIFIC STAFF

required at

A.W.R.E., FOULNESS, ESSEX

The work at Foulness, in addition to covering a wide variety of problems associated with weapons and weapon effects, offers several other interesting and stimulating problems. Typical examples are:—

(*a*) Reactor Containment—model scale experiments to test the effect of pressure excursions on reactor structures.

(*b*) Explosion Studies—theoretical and both model and field experimental studies of the behaviour of materials under explosively generated high stress pulses.

(*c*) Properties of materials at high pressure—experimental studies of the effects of high pressure shock waves, generated by explosives, upon the physical properties of solids, liquids and gases. The work presents challenging problems in devising techniques to observe the physical processes in materials under these conditions.

Applicants should have an honours degree. A good knowledge of physics and the ability to apply it to these practical problems are required rather than previous specialist experience in these fields. Much of the work is unclassified and staff are encouraged to publish reports on their work. Contact is maintained with Universities and Laboratories, both in the U.K. and overseas, working on similar problems.

Appointment will be made to the Scientific Officer class, with salary in the range £790–£1,770, according to age, qualifications and experience.

Superannuation, housing and house purchase schemes.

Please write for application form to

The Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks.,

quoting ref. 2965/110.

MAKERERE UNIVERSITY COLLEGE

EAST AFRICA

Applications are invited for appointment to the Chair of Physics. Salary £3,000 p.a. F.S.S.U. Child allowance £50 p.a. per child (max. £150 p.a.). Passages for appointee and family (up to 5 adult passages) on appointment, termination and leave (3 months every 21 months). Rent according to quarters provided £45 to £84 p.a. (including basic furniture). Detailed applications (8 copies) naming three referees by November 10, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY LONDON

DEPARTMENT OF APPLIED PHYSICS

Applications are invited for the post of TECHNICAL ASSISTANT to assist in research on Subjective Brightness. The work is being sponsored by the D.S.I.R. and the appointment is in the first place for three years. Applicants should hold a University Degree or equivalent qualifications. Ability to assist in the construction of research apparatus is essential. Salary £800 p.a. Application forms and further particulars may be obtained from the Head of the Applied Physics Department, Northampton College of Advanced Technology, St. John Street, Clerkenwell, London, E.C.1.

THE BRITISH CERAMIC RESEARCH ASSOCIATION

SPECIAL CERAMICS

There are several vacancies in this newly formed and expanding Division of the British Ceramic Research Association for Senior Scientific Officers, Scientific Officers and Senior Technical Officers. Graduates in Physics and/or Chemistry are preferred; experience in ceramics is not essential. The work covers the development of new materials, e.g. non-oxide ceramics, inorganic polymers, refractory coatings, etc., the assessment of their properties and their potentiality in electronic components, rocketry, nuclear power and general engineering. Excellent facilities are available for this work and publication is encouraged. The posts are permanent and progressive and carry superannuation provision under the Federated Superannuation System for Universities. Salary will depend on age, qualifications and experience but will be in the range of :— S.T.O. £850 – £1,150. S.O. £730 – £1,150. S.S.O. £1,200 – £1,650. Applications giving details of age, qualifications and experience should be sent to the Director, Dr. N. F. Astbury, The British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

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Plato or Paracelsus? The Physicist's Dilemma

J. M. A. LENIHAN

M.Sc., Ph.D., A.M.I.E.E., F.Inst.P.

Regional Physicist, Western Regional Hospital Board, Glasgow

NE supra crepidam sutor iudicaret, advised Pliny : let the cobbler stick to his last. In physics, as in many other activities of the intellect, interesting and even diverting experiences are sometimes achieved by ignoring this proverbial wisdom. The physicist who works in the hospital service finds ample opportunity to practise his craft and extend his knowledge in unfamiliar realms.

The study of forensic medicine is, to the uninitiated, something like the witches' sabbath described by Scotland's poet in *Tam O'Shanter :*

> Five tomahawks, wi' bluid red-rusted ;
> Five scimitars, wi' murder crusted;
> A garter, which a babe had strangled;
> A knife, a father's throat had mangled,
> Whom his ain son o' life bereft,
> The gray hairs yet stack to the heft;
> Wi' mair o' horrible and awfu',
> Which even to name wad be unlawfu'.

To the initiated it may look much the same, but there is a great deal to be done by the application of scientific ideas to the detection of crime.

Arsenic, long notorious as an instrument of homicide, has lost ground to subtler means of despatch among educated poisoners, but its administration has been alleged or suspected in a few celebrated cases during the last few years. The development of more sensitive analytical methods is still worth while and work was begun in Glasgow some seven years ago to establish a technique for estimating arsenic in biological materials by activation analysis.

Most of the physical and chemical properties of a material depend on the behaviour of its extra-nuclear electrons. The properties of the nucleus—often highly specific for the element concerned—may be elicited throughout most of the periodic table by bombardment with neutrons. For nearly all of the elements between $Z=10$ and $Z=80$ (and a few outside these limits) the induced radioactivity after exposure to a brisk dose of neutrons is readily detected, even when the sample is small. Sensitivities of 10^{-10} gm are common and even better results can be obtained for some elements. If the original sample contains a number of elements, the induced activity is complex, but adequate discrimination can be achieved by chemical manipulation of the irradiated material, reinforced if necessary by γ-ray spectrometry.

Using the Harwell reactor, with chemical techniques devised for the purpose, it soon became possible to estimate arsenic in human tissues with accuracy and sensitivity beyond the reach of existing methods. These resources were used in one criminal investigation (which was unspectacular) and in a number of other projects which yielded surprising results.

At an early stage in the experimental work, it was decided to establish normal levels for arsenic concentration in human hair. Most authorities are reticent or inadequate on this point, since much of the available information is derived from victims of arsenical poisoning. The live and uncontaminated subject will seldom part with enough hair to satisfy the analyst who uses traditional chemical methods of estimation. For activation analysis, a single hair is enough and the collection of samples is not difficult.

In the first trial of the new method, hair from a dozen members of a hospital staff was used. Most of the samples showed arsenic at levels below 1 part per million but concentrations as high as 40 ppm were found in a few. These anomalies were promptly attributed to experimental carelessness and arrangements were made for a further modest epilation of the volunteer subjects. The results were roughly the same, with most of the samples giving arsenic levels within the expected range and a few showing very much higher concentrations, never before observed in the living.

The anomalous returns came from female laboratory attendants and it was next supposed that some external contamination of the hair might have occurred from contact with chemicals or with materials used in the animal house. Accordingly each sample in the next batch was divided in two. One half was washed before exposure to neutron bombardment and the other was sent to Harwell without any preliminary treatment. This time the answers were even stranger. Among the unwashed samples, the arsenic levels followed the pattern already observed, with a few high values and the rest unexceptionable. The washed samples all showed high concentrations of arsenic.

The solution of this puzzle, obvious though it now

seems, took a couple of weeks. It was then decided to examine the detergent used to wash the hair samples. This material, bearing a name which is literally a household word, was found to be rich in arsenic. Further samples bought in shops gave similar results on analysis. The explanation was not hard to find, for Lord Kelvin had been involved in a somewhat similar mystery as chairman of a Royal Commission which investigated an outbreak of poisoning among Lancashire beer-drinkers in 1900. Six thousand people were affected and the causative agent was soon identified as arsenic. It reached the beer in glucose, made by treating starch with contaminated sulphuric acid. Arsenic is a common impurity in sulphuric acid made by the lead chamber process ; it comes in the first place from pyrites.

Many detergents are based on sulphated or sulphonated oils ; impurities in the sulphuric acid might well find their way into the final product, along with the more widely-esteemed and exotically-named ingredients. Dozens of detergents were analysed but only two (from the same maker) showed high concentrations of arsenic. A note of the findings, sent to the manufacturer with an intimation that comments or corrections would be appreciated, brought a polite acknowledgement. After an interval of some months it was suggested that discussion might be useful since it was intended shortly to publish the findings. The chief chemist and the sales manager arrived without further delay and confirmed that arsenic was indeed present in the detergents and that it had arrived by the route already suspected. Changing the source of sulphuric acid would be so costly as to take all the pleasure and profit out of the manufacturing process. The change was nevertheless made and the concentration of arsenic gradually fell (in samples bought unobtrusively over the next year) from 70 ppm to 1 ppm. The prosperity of the manufacturer continues, by all outward signs, at a pleasantly satisfactory level. It remains to explain the anomalous findings that initiated this train of thought and enquiry. The laboratory workers in whom such high arsenic levels were found had the habit of purloining the laboratory detergent for washing their hair. This irregularity has now been discouraged.

Activation analysis was used in another investigation designed to illuminate the supposed correlation between smoking and lung cancer. Arsenic is the only constituent of tobacco smoke known to be capable of causing cancer in the human subject. Other substances found in tobacco are carcinogenic in animals and may have the same effect in man, though positive proof is lacking. Arsenic arrives in tobacco by way of the insecticides used in many countries to spray the growing leaves. Concentrations as high as 40 ppm have been found in cigarettes but normal levels are a good deal lower, particularly since manufacturers became aware of the possible hazard a few years ago.

A heavy smoker will take in a substantially greater amount of arsenic than a non-smoker; does it stay in his body or does it come out again ? If it leaves the body, an enhanced concentration in the hair should be demonstrable (since hair, skin and nails are among the main escape routes for the element). To test this hypothesis, 1000 samples of hair were obtained from hospital staffs and patients, university students and other members of the public. Information on the smoking habits of the subjects was also collected, but concealed from the analysts until the end of the experiment. The samples were weighed, sealed into individual plastic bags (after discarding a few offerings of string, horse hair, doormat fibres and other adventitious material submitted by the student body !) and sent to Harwell for irradiation, along with small amounts of arsenious oxide to form a basis for the subsequent quantitative estimation.

When the analysis was complete, the figures were compared against the information already collected on the subjects' smoking habits. As between the smokers and the non-smokers, there was no significant difference. When the cards were re-sorted to find whether there was any real difference in arsenic concentrations between men and women, an unexpected result emerged. For women the arsenic level in hair had a median value of about 0·35 ppm; for men the corresponding figure was nearly 0·6 ppm. The reason for this difference has not been explained but more work remains to be done ; evidence is accumulating that arsenic (in tobacco smoke or in general atmospheric pollution) may be a significant factor in the lung cancer problem.

Another aspect of the public health which often brings work to the hospital physicist is the radiation hazard. Carelessness and inadequate supervision are the usual causes of mishap. Seriously alarming incidents are rare, though the most interesting accidents are seldom reported in the newspapers.

A telephone call early one morning told of a curious occurrence at an engineering establishment, where a man using a 300 mc source of ^{137}Cs was believed (on the evidence of a pocket dosemeter) to have been exposed to radiation during the course of his work on the radiographic examination of metal structures. Inspection showed measurable contamination of clothing and skin, alleviated by vigorous bathing and the gift of a new suit from the management. Gross contamination was found on the handling tools used with the source and in the dark room. Other workers who had used the same source were assembled for estimation of body radioactivity, using a crude measuring device consisting of four large Geiger counters mounted vertically at the corners of a light metal cage and connected to a ratemeter. On the basis of these measurements, further investigations were made by the Radiological Protection Service. One of the workers took part in an important experiment to establish the rate of excretion of caesium from the body—a matter on which previous evidence was ambiguous. His body burden—16 microcuries of ^{137}Cs at the time of the measurement—was enough to allow for the first time, accurate estimation of the biological half-life and there fore of the maximum permissible level of internal contamination by this isotope.

In discussion with the users of the source it was learned that two identical capsules of ^{137}Cs had been obtained some time previously. To begin with, they gave very similar results radiographically but it had been observed that a gradual lengthening of the exposure time was necessary for one of the sources, in order to obtain comparable pictures. Inspection of the faulty source, made by the original suppliers, showed that its metal

casing was cracked and was a little shorter than when new. The apparent cause of all the trouble was the action of a worker who, finding the capsule reluctant to slip into its seating at the distant end of the handling tool, gave it a sharp tap on the ground by way of encouragement. During the succeeding months a large part of the radioactive material was dispersed, most of it landing in places where no great harm was done.

An interesting feature of this incident was the absence of any effective official provisions for maintaining safety in handling the radioactive material. Regulations as to storage, inspection and transport of the powerful sources often used industrially had not been issued at the time of the accident and are still only in draft form.

More recently a tube containing 10 mg of radium disappeared from a hospital. Intimation of the loss was first given eight days after the last positive sighting of the source—inside a patient receiving radium treatment. Its subsequent fate was a matter of conjecture. Inspection of the hospital revealed no unusual radioactivity in waste bins, sink traps or incinerators. Experience suggested that the missing tube had probably been discarded with soiled dressings, consigned to the dustbin and thence to the hospital furnace from which the ashes were collected daily for disposal elsewhere.

Discussion with the Medical Officer of Health and the Director of Cleansing showed that the harvest gathered by the refuse carts was taken first to a destructor handling a large part of the city's rubbish in several furnaces. The fires were extinguished and the ashes raked out so that a survey might be made with Geiger counters. This duty occupied a Sunday morning for three searchers walking (like Meshach, Shadrach and Abednego) the fiery furnace to and fro ; the temperature, though much abated, was still uncomfortably high. The rest of the works, an area of several acres suffused with an effluvium of indescribable richness, was examined with dwindling enthusiasm and yielded nothing. On the following day the search was transferred to an ash tip some 15 miles away, where the missing source was eventually found, unharmed by its attempted incineration and comminution.

The foregoing paragraphs are, as the reader may have surmised, based on the experiences of the Regional Physics Department in Glasgow, a sizeable company appointed to serve many Scottish hospitals. The work of the unit has increased substantially in scope and volume since a progress report was last given in these pages five years ago ; some of the projects then beginning have now come to fruition—or at any rate to maturity.

Acoustics, a branch of physics now widely neglected, is important to those concerned with maintaining or improving the public health. About two per cent of the population have defective hearing. Severe deafness is easily recognized but accurate diagnosis in other circumstances demands careful measurement of the auditory threshold at several frequencies—a task which is complicated by the difficulty in establishing and preserving adequate standards. Loudness is not easily specified in any objective way and there is still no international agreement on standards for clinical use.

In principle the measurement of hearing threshold is quite simply done with an audiometer, comprising an oscillator, an attenuator and an earphone. In practice it is difficult to secure conformity to any agreed standard. A British Standard Specification was issued in 1954, permitting auditory thresholds for normal hearing to be reproduced in any laboratory suitably equipped. In 1957 the audiometers in Scottish hospitals (50 in number) were collected for inspection. Not one gave output levels within 3 dB of the approved values at the test frequencies; errors of 10, 15 or 20 dB were common. When these defects had been remedied, sometimes by extensive rebuilding, fresh calibration was found necessary at six-monthly intervals—mainly because of random changes in earphone sensitivity under normal working conditions. No manufacturer in the world makes earphones of adequate stability (in sensitivity and frequency response) for audiometric work.

Early recognition of deafness is particularly important in children since much can be done by prompt action to alleviate the otherwise inevitable educational and social disabilities. Some education authorities are enterprising in this matter, but others do not even test the hearing of the school children. When tests are done without the support of accurate acoustical standards the results are often dubious. When 40 audiometers used in Scottish schools were examined in 1959 and 1960, not one had output levels within 3 dB of the current British Standard; many were so inaccurate that children with hearing losses of 20 or even 30 dB would have been passed as normal in the sweep tests generally made in school. Here, as in other parts of the health service, the benefits gained by application of simple physics are immediate and striking.

Radiation hazards or accidents calling for emergency action have already been mentioned; much can be done to avoid such excitements by timely instruction and exhortation. Regular courses are offered in Glasgow for groups of people likely to encounter radiation hazards in a technical or administrative capacity—firemasters, water engineers, medical officers of health and ward sisters. Longer and more arduous courses are given on such topics as the use of radioactive isotopes in medical and biological research. Here the students—mostly senior members of hospital or university staffs—arrive with a breadth of knowledge and experience that is sometimes disconcerting In the final test given to a recent group the question was asked: "Design an experiment using radioactive isotopes to estimate the blood volume of an elephant". One knowledgeable answer was prefaced by the intimation: "I have already done this experiment". The student, a veterinary surgeon, had indeed done something very similar during his service as second-in-command of an Elephant Company in Burma during the war !

In the hospital service the provision of specialized facilities for research or treatment generally stimulates further demand. The Regional Physics Department, conforming to this trend, has increased substantially since its inception less than eight years ago. (See Table I on page 288.)

Where this process of growth will reach equilibrium is hard to foretell. In the long term it seems likely that the employment of physicists in the service of medicine must increase as the employment of chemists and biochemists has done during the last half-century. The early scientists

Table I

Growth of staff in the Regional Physics Department, Glasgow, since 1953

*Establishment of staff on 1 January**

Year	*Physicists*	*Chemists and biochemists*	*Other science graduates*	*Technicians*	*Administrative staff*	*Total*
1953	1					1
1954	3			2		5
1955	5		2	4	1	12
1956	7		2	7	1	17
1957	8	2	2	11	1	24
1958	10	2	4	11	2	29
1959	10	4	2	12	2	30
1960	13	4	4	14	3	38
1961	17	6	6	17	4	50

were nearly all doctors and their successors have not been slow to take advantage of scientific aids towards the relief of suffering. It would be strange if the ideas and methods of physics did not spread into the realm of medicine as they have spread into so many other aspects of twentieth-century civilization.

The activities described in the preceding pages are a small illustration of a general tendency which has been conspicuous during the last half century and which raises the question: What is the purpose of physics ? Two conflicting views may be summarized (with slight exaggeration for greater clarity) by recalling the philosophies of Plato and of Paracelsus.

* The present establishment (October 1, 1961) is 63, including 38 science graduates and 20 technicians.

For Plato and his followers, virtue was synonymous with knowledge. A good man could not be other than a learned man. Mathematics—the discipline which then represented the furthest reach of the mind—was to be taught for the advancement of learning; practical applications were deprecated. To-day he would insist that theoretical physics should occupy an eminent place in the curriculum. He would dismiss the daily activities of many members of the Institute and Society as not deserving to be classified with the true learning.

Paracelsus, the eccentric sixteenth century physician, had very different views—expressed with a confidence and panache that have never been emulated. The principle doctine of his teaching was that he was right and everyone else was wrong. Appointed in 1527 as municipal physician and lecturer at Basle, he scandalized the academic community by a demonstration on the day of the students' annual rag, when he publicly burned the works of Avicenna in a brass pot. " Come, then " he invited his colleagues, " and listen, impostors who prevail only by the authority of your high positions ! " They listened, and some of his words were good sense. " Many have said of alchemy ", he wrote, " that it is for making gold and silver. For me such is not the aim, but to consider only what virtue may lie in medicines ". By insisting that the object of alchemy was to make drugs for the relief of suffering, he established the rational basis of medicine—and indeed of chemistry, for the spectacular failure of uncontrolled treatment with arsenic, antimony, mercury and other Paracelsan remedies led to the concepts of chemical purity and of quantitative measurement.

For Paracelsus, knowledge was nothing, except as the instrument of purposeful action. Is this the proper function of science to-day ? Or is the advancement of learning all that matters ? Happily we may each choose for ourselves.

October 1961

First Year Physics for Diploma in Technology Students of Mechanical Engineering

C. A. HOGARTH
B.Sc., Ph.D., F.Inst.P.
and
D. J. REES
B.Sc., A.Inst.P.
Department of Physics, Brunel College of Technology

THERE is a general trend in engineering courses to include more and more basic engineering sciences at the first degree or diploma level. Whereas in university courses in engineering, students will in general have taken at least physics and mathematics to the advanced level of the General Certificate of Education, this is not always so in the case of students who are taking courses for the Diploma in Technology. In this college, for example, approximately half the students entering on mechanical engineering courses for the Dip. Tech. hold Ordinary National Certificates or Ordinary National Diplomas in Mechanical Engineering. The problem of how to treat first year students when teaching them basic engineering physics has therefore arisen over the last few years. One approach is to give the students holding an O.N.C. in Mechanical Engineering a short " potted " course in physics pitched somewhere midway between Ordinary and Advanced levels of the General Certificate of Education. Such a course is obviously unsuitable for holders of A level physics and furthermore has the disadvantage of separating students into two " social " groups one of whom believes itself to be intellectually superior to the other. We consider that there is much to be gained from students operating as one class and pursuing a common course regardless of their previous educational background. To this end, when confronted with the problem of arranging a first year course in engineering physics for students of mechanical engineering we have tried to construct a syllabus which, while providing a good basic treatment of suitable topics in physics, would be of interest to A level students and within the intellectual range of the O.N.C. students. It must be remembered that the O.N.C. students will already have met some topics normally included in a physics course. These will include: mechanics, simple properties of fluids and some electricity and heat. They will, however, have met little optics or acoustics, and most of the topics they will have studied will have been treated by largely ad hoc methods. Nevertheless it must be borne in mind that O.N.C. students taking a Dip. Tech. course are the very best O.N.C. students. In other words, they will have achieved an average mark of at least 65 per cent in the O.N.C. examination with not less than 60 per cent in any one subject.

In planning our course we have taken the view that even the holders of A level passes in physics are not always well informed about the fundamentals of the subjects in which they have passed examinations and furthermore that certain topics may be included which are traditionally not taught normally at school level and yet which are of very great practical importance to engineers and are within the intellectual range of first year students. Such topics would include simple ideas of crystal structure and the effects of dislocations. Treatments of these subjects can be essentially descriptive and can be of great value to students of engineering. In our course as developed probably a third of the material included ought to be familiar to students with a previous knowledge of physics to advanced level G.C.E. but by emphasizing those points which are important, and often neglected, they can gain a much greater understanding of basic physical principles used in engineering.

Thus we consider that it is possible to plan a course which is satisfactory in content as part of a mechanical engineering course, requires the intellectual effort appropriate to a course at Diploma in Technology level, and will maintain and stimulate interest in the subject regardless of the students' backgrounds.

The principles which we have borne in mind in planning the course are as follows. The syllabus must treat topics which relate to mechanical engineering and which are not treated in detail elsewhere in the first year of the course. Emphasis must be placed on the physical principles of the subject, keeping the mathematical treatment to a minimum. This does not mean that mathematics is avoided but rather that care is taken to ensure that the topics do not merely become mathematical exercises to be solved by memory or ad hoc method. In general the applications of the topics to engineering are indicated in general terms but not discussed in detail. This can be done more appropriately as part of the engineering subjects as we think it is wrong to give these applications an undue prominence in what is predominantly a physics course.

The syllabus which we have drawn up is as follows:—

ENGINEERING PHYSICS, FIRST YEAR

Heat

Temperature. Scales of temperature. Thermometers including mercury-in-glass, thermocouples, thermostats, resistance thermometers, gas thermometers, pyrometers, optical pyrometers. Hot wire anemometer.

Light

General details of optical instruments such as telescope and microscope, referring to those with internal scales and to errors of adjustment. The crystalline

state. Defects in crystals. Electromagnetic spectrum. Photometry. Polarisation and the study of stress birefringence.

Sound

Wave motion. Propagation of sound waves in solids, liquids and gases. Measurement of sound intensity and loudness. Decibels.

Fluids

Physical properties of fluids. Surface tension. Viscosity. Compressibility.

Atomic Theory

Nature of matter and of atomic and nuclear particles and radiations. Radioactive tracers.

Electricity

Application of Wheatstone bridge and potentiometric circuits to thermocouples, strain gauges, and hot wire anemometry.

Principles of conduction of electricity in solids and of emission of electrons from solids. Effects of temperature and light.

The time allowance for teaching this syllabus is 2½ hours a week for 24 weeks. This is arranged as one lecture per week, and 3 hours for laboratory and tutorial purposes for half the class on alternate weeks.

In the interpretation of this syllabus we have endeavoured to teach the topics in such a way that even if a student has met certain subjects previously, he still finds them of interest. To illustrate this we may refer to a few particular topics which many of the students will have studied previously.

(i) *Optical Instruments.* We have found that because of their previous training most students who have taken A level Physics are capable of performing quite involved calculations concerning the relative positions and magnification of objects and images produced by microscopes and telescopes. In spite of this our experience shows that most students have a very poor idea of the physical principles upon which these instruments are based. To take the simplest case as an example, no student we have yet spoken to has been able to give a good account of how one observes an image of a real object by the use of a simple convex lens, and to explain how to view with the eye a real image produced in such a lens, or to appreciate the case when the eye is placed close to the lens. When such fundamental ideas have been so little understood, it is not surprising to find that the understanding of the physical principles of optical instruments provides a useful subject for discussion to these classes. In this respect it may well be that the students who have never before met lens calculations are at some advantage because they can bring an unprejudiced mind to the subject! We discuss without mathematical detail the relationship between object and image distances in lenses and it is not difficult to lead to Newton's Formula. This illustrates the advantage to be gained in certain cases by a suitable choice of axis, and is often of interest as a different mode of expressing the more familiar

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

relationship.

(ii) *Polarisation.* This is a topic which causes much interest and here the photoelastic stress analysis techniques are described. (It is always interesting to notice how few students who have studied the subject of polarisation realise that a plane polarised wave contains both E and H vectors!)

(iii) *Illumination.* Certain topics such as illumination have been found to be amenable to group work. For example, the variation of illumination on a plane under two sources of light mounted above the plane depends, of course, on the spacing of the sources. If each student performs the necessary calculation for a particular lamp spacing and each draws the illumination curve to an agreed scale, it is possible to have a single record which shows the variations involved. These students have proved to be very interested in group work of this type and we hope to extend this method.

(iv) *Electromagnetic spectrum.* Some students will have ideas about the wavelengths of visible light but will probably have hazy notions about radio waves and X-rays. By means of a general account of electromagnetic spectrum from γ-rays through to long radio waves several useful objects are achieved. The lengths appropriate to various physical phenomena are seen in relation to those appropriate to others, a logarithmic scale is usefully employed to demonstrate the different regions of the spectrum and the utility of such a scale is demonstrated, and the range of numerical values of wavelengths and frequency encountered in physical phenomena may be simply calculated. The measurement of length is, of course, of great importance to a mechanical engineer.

Although the syllabus contains a number of topics which have been previously studied by many of the students, it will also be noted that a number of subjects will be new to all students. These of course do not, present the educational difficulties involved in maintaining the interest of the students to the extent of the subjects with which the student already feels familiar. We will briefly discuss three of these topics as examples.

(i) *Atomic Physics.* In view of the widespread and increasing use of radioactive materials in industry, and of the importance of the use of atomic energy for power purposes we feel that these students should be introduced to elementary atomic physics as soon as possible. There is no difficulty of interest here, as the importance and topicality of the subject is already appreciated by the students. We deal with atomic structure, radioactivity, nuclear fission, and the principles of the use of nuclear energy for power production. This has always been a popular part of the course, and in tutorials discussion has ranged a good deal wider than these remarks might indicate—from why does the nucleus hold together (!) to what are the hazards from radiation?

(ii) *Solid State Physics.* Again we have found in this a topic which is of fundamental importance and which

can be dealt with in a way which can be appreciated by these students. The basic ideas of diffusive motion of free charge carriers, their collisions, and their effects on electrical conductivity can be simply introduced. The origin of free charge carriers in metals and semiconductors is simply explained starting from the shell model of the atom and a plausible discussion of the effects of the very close interatomic spacings (of order 3×10^{-8} cm) appropriate to many solid materials at room temperature. Most students will have to become acquainted with electronic devices, and with the present trend towards the use of solid state devices such as junction diodes and transistors, it is as important to give some basic ideas of the motion of holes and electrons in solids as it is to explain the more conventional ideas of the motion of electrons in vacuo.

(iii) *Crystallography.* Simple ideas of the crystalline state relate quite usefully to (ii) above and give students a rather better idea of how physical materials are bound together than is given by the usual courses in physics at elementary levels. In recent years there has been a trend in physics and engineering to study solid materials in monocrystalline or highly perfect form. The effects due to crystalline imperfections or impurities can then be assessed. Imperfections such as dislocations, which are important as possible origins of fatigue cracks and as agents for the work hardening process can then be usefully discussed with mechanical engineering students in this course. The subject matter is not too difficult, it is very topical and relevant to the parent subject, it lends itself to logical and qualitative treatment, and students find it interesting.

The course in practical physics is integrated with the lecture course as far as possible. We lay emphasis on experiments to illustrate the principles discussed in the lectures and on the writing of clear and concise reports of work done.

We have included experiments on the following subjects:

1. Viscosity measurements—Reynold's Number.
2. Surface Tension measurements.
3. Optical Instruments—their basic design.
4. Polarimetry.
5. Temperature measurement, thermocouples, etc.
6. Radioactivity—the use of Geiger counter.
7. β- and γ-ray measurements; the absorption of radiation.

Generally speaking, we have found that students work well in the laboratory, and that it is a mistake to try and make the work too elementary. Thus students enjoy carrying out experiments on the detection of nuclear radiations and will usually work energetically and write excellent reports. Indeed from their previous training and general engineering attitude to report-writing, these first-year students often prepare more lucid accounts of experimental work than do first-year students of physics. We have arranged to carry out certain experiments on a " team " or " group " basis. The success of this approach has suggested that more work of this kind can be introduced in the future.

To summarise the above remarks, we believe that it is possible to construct a course of useful engineering physics for first year students of mechanical engineering. The course can be taken with advantage by students of various backgrounds and will in general be of interest to all. The course is still under development and we do not claim to have reached perfection. Nevertheless, knowing that the problem of developing such a course has arisen in various institutions in this country and in the U.S.A. we hope that the above brief account of our approach to a solution of the problem may be of use in stimulating ideas elsewhere. We should like to acknowledge the encouragement we have received from Dr. J. Topping in this work.

Students' Evening — Midland Branch

At the first Students' Evening of the Branch, on April 12, papers were presented by two young members—Mr. D. E. Kidd, a research student in the Physics Department at Birmingham University and Mr. D. J. Moppett, a Dip. Tech. student at the Birmingham College of Advanced Technology.

Mr. Kidd spoke about the development of the radial ridge cyclotron, work which involves large-scale equipment typical of the nuclear physics laboratory, and which necessarily involves a great deal of co-operation with other team members. On the other hand, Mr. Moppett's research on the work function of metallic films was carried out on small scale laboratory equipment.

Although these aspects of the work were so different, the standard of presentation of both papers was high, and both authors dealt ably with the questions and discussion which ensued.

The success of this meeting has encouraged us to repeat the experiment in our program for 1961-62, and we hope that this might stimulate other Branches to follow suit.

Brief summaries of the papers, supplied by the authors, follow:—

THE RADIAL RIDGE CYCLOTRON (D. E. KIDD)

The conventional cyclotron (first operated successfully in 1932) depends for its operation on the fact that the cyclotron frequency given by

$$w = \frac{He}{m}$$

is independent of the particle velocity. It was soon realized however that to obtain useful beam intensities, focusing was required to prevent beam loss to the dees and vacuum chamber walls. Focusing was first achieved with a magnetic field which decreased slightly with radius, causing the lines of force to bow as shown in Fig. 1. A field increasing with radius produces defocusing.

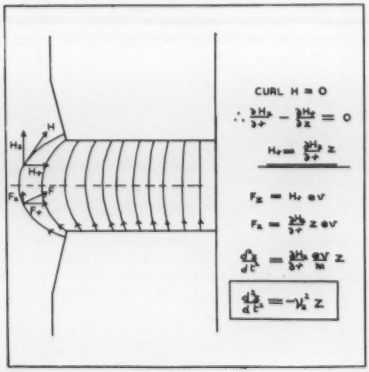
CURL H = 0
$\therefore \frac{\partial H_R}{\partial z} - \frac{\partial H_z}{\partial r} = 0$
$H_R = \frac{\partial H_z}{\partial r} z$
$F_z = H_z \, ev$
$F_R = \frac{\partial H_z}{\partial r} z \, ev$
$\frac{d^2z}{dt^2} = \frac{\partial H_z}{\partial r} \frac{ev}{m} z$
$\frac{d^2z}{dt^2} = -\mu_R^2 z$

FIG 1

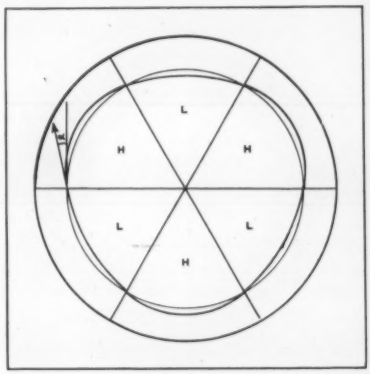

FIG 2

A focusing field therefore does not maintain a constant cyclotron frequency, so that particles fall out of phase with the accelerating voltage. This change of phase is speeded up by the relativistic mass increase at high energies, so that the maximum energy and beam intensity of a conventional cyclotron are severely limited.

In 1938 L. H. Thomas showed theoretically that a field having an azimuthal variation of sinusoidal form could provide enough focusing to overcome the defocusing effect of a slight radial increase in the field, thereby allowing particles to reach relativistic energies. The Birmingham Radial Ridge cyclotron is a development of this, and has three high and three low field sectors, providing a field variation closer to a square wave than a sinusoid. The shape of a closed orbit in an ideal square wave field is shown in Fig. 2.

A more general argument than that in Fig. 1 shows that a field is at least axially focusing in any region in which the field gradient along the outward drawn normal to the orbit is negative. Examination of Fig. 2 reveals that this is the case every time the particle crosses a sector boundary. In this case radial focusing is also achieved.

The Birmingham machine has magnet poles of 40 in. diameter, and gaps of 3½ in. and 5½ in. giving fields of 18·5 K gauss and 12·5 K gauss in the high and low field sectors respectively. The mean field is 15·5 K gauss. Current carrying coils on the pole face can alter the field shape to give a mean field radial increase of 1·1% for accelerating He_3, 0·65% for deuterons and 0·2% for N_{14}. A peak voltage of 30 KV. on the single dee accelerates He_3 to 30 MeV, deuterons to 11 MeV and N_{14} to 25 MeV.

CONTACT POTENTIAL MEASUREMENTS (D. J. MOPPETT)

The dependence on thickness of the work function of a metallic film has not been extensively studied. This problem has now been attempted for an evaporated copper film by

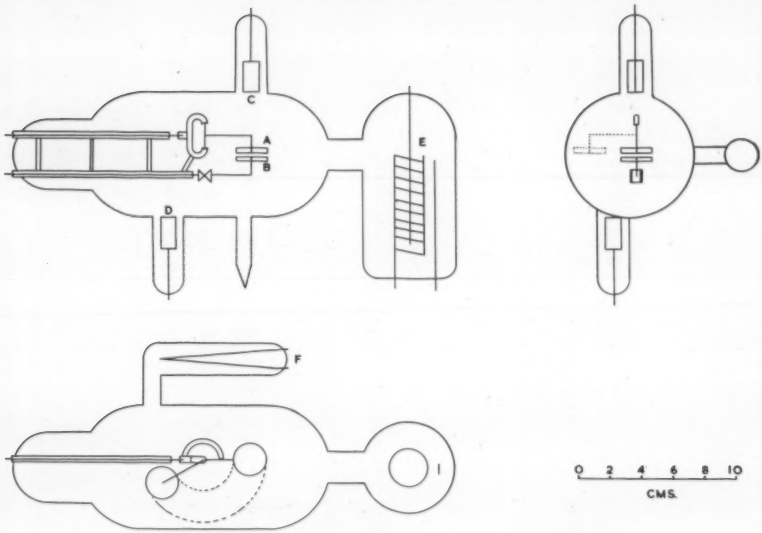

FIG. 3. Experimental tube A. Swinging electrode B. Vibrating electrode C. Gold evaporator D. Copper evaporator E. Alpert pump F. Molybdenum getter

following the changes in contact potential difference produced between this film and a gold reference surface. The Kelvin vibrating condenser method was chosen for measuring the contact potential difference in preference to the Anderson electron beam method because of the comparative simplicity of the experimental tube as well as the fact that the latter method may be adversely affected by patchy surfaces. The experimental tube, Fig. 3, was constructed in hard glass and an Alpert gauge enabled an ultimate vacuum of the order of 10^{-9} mm.Hg to be achieved. After suitable impedance conversion the low frequency signal from the tube was amplified and presented on a commercial oscilloscope making it possible to measure the contact potential difference to within $\pm$ 2 mV.

Three measurements of contact potential difference were made, and values of 63, 173 and 265 mV with the copper negative with respect to the gold were observed as the thickness of the copper film was increased. Assuming a value of 4·70 eV (Rivière)* for the work function of gold, these results indicate that the work function of the copper decreased as the thickness of the film increased. The thickness of the final film was estimated to be approximately 1500 Å and only at this thickness was there reasonable agreement with other published values for the work function of copper. Furthermore even at these relatively low pressures the effect of gas contamination was observed both after evaporation of the film and after further Alpert pumping. It is hoped that further work will enable these problems to be studied in more detail.

* J. C. Rivière, *Proc. Phys. Soc.* B**70** 1957 676

Notes and News

Annual Exhibition of Instruments and Apparatus

The dates of the Annual Exhibition, to be held at the Royal Horticultural Society's Halls, are January 15-19. Full details and tickets will be circulated with the November *Bulletin*.

Symposium on " Some Aspects of Vacuum Science and Technology "

In the announcement of this Symposium on p. 245 of the September *Bulletin*, the scope was stated as (*a*) Continuously exhausted bakeable vacuum apparatus for pressures below 10^{-9}mm. of mercury, and (*b*) The controlled deposition of evaporated film.

It is now found that it will only be possible to cover the first of these items on January 5. Consideration is being given to including the second in a future symposium.

Conference on " The Ionosphere "

The Institute and Society is arranging a conference on " The Ionosphere " to take place in London from July 2 - 6, 1962. It is intended as a working conference and no social activities are planned. The subjects to be covered and the opening speakers are :

(*a*) Ionospheric constitution and ionizing radiations — Dr. H. Friedman of the U.S. Naval Research Laboratory, Washington ;

(*b*) Geomagnetism and the ionosphere — Dr. C. O. Hines of the Defence Research Telecommunications Establishment, Ottawa ;

(*c*) Irregularities in the ionosphere — Dr. B. H. Briggs of the Cavendish Laboratory, Cambridge ;

(*d*) Mathematics of wave propagation through the ionosphere — Professor H. G. Booker of Cornell University.

Each of these principal sessions will be opened by the named speaker and offers of other contributions are invited. These should be accompanied by an abstract of 100-150 words each and be sent to the Chairman of the Organizing Committee, Mr. J. A. Ratcliffe, F.R.S., at the Radio Research Station, Ditton Park, Slough, Bucks, before March 1 next. The final scripts will be required by June 1, 1962, and it is hoped that publication of the proceedings of the conference will take place very soon after the close of the conference. The official languages of the conference will be English and French but whenever possible papers and abstracts should be presented in English. The organizers are not proposing at present to make any special arrangements for accommodation for those attending the conference. Those wishing to do so are strongly advised to book hotel accommodation in London very early in the New Year.

Further particulars will be available at the end of March.

Australian Branch Committee

We are glad to publish the photograph reproduced below of the Committee of the Australian Branch of the Institute and Society. Because of the distances involved, the full Committee can meet only infrequently; much of its work must be done by correspondence.

World Directory of Crystallographers

The *World Directory of Crystallographers*, published by the International Union of Crystallography, is still avail-

The Committee of The Australian Branch

Top Row: *Drs. R. I. Garrod, D. E. Caro (Chairman), J. L. Farrands and J. K. Mackenzie (all of Victorian Division), Dr. J. H. Carver (Australian Capital Territory), Dr. R. W. E. McNicol (Chairman, Queensland Division), Mr. W. R. Blevin (Hon. Secretary, New South Wales Division), Mr. E. R. Johnson (Chairman, South Australian Division).*

Bottom Row: *Dr. S. E. Williams (Vice-Chairman, Western Australian Division), Mr. A. F. A. Harper (Hon. Secretary, Australian Branch), Dr. J. L. Pawsey, (President, Australian Branch), Mr. G. A. Bell (Hon. Treasurer, Australian Branch), Mr. J. M. Rayner (Chairman, Australian Capital Territory Division).*

able from Headquarters. Members who would like a copy at the reduced rate of 8s. 6d. should send their orders with remittances to the Publications Department of the Institute and Society.

Seminar on the Physical Science Study Committee Course

The Physics course for schools developed by the American P.S.S.C. has been the subject of a great deal of interest in European countries. Readers of the *Bulletin* may remember the enthusiastic review of the P.S.S.C. Textbook published in March 1961. The Organization for European Economic Co-operation, which has done a good deal to support work on new methods of teaching science, sponsored a four week seminar on the P.S.S.C. course which took place in the Clarendon Laboratory, Cambridge, through the very kind co-operation of Professor N. F. Mott and Dr. Nicol, in August. Thirty-four teachers of physics took part and worked through the whole of the course including the practical work. Lectures on the course were given by Professor U. Haber-Schaim and Professor F. Friedman of the Massachusetts Institute of Technology, Professor P. Morrison of Cornell University and Mr. J. B. Cross, an American schoolteacher.

The following countries were represented: Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and Yugoslavia. The United Kingdom representatives were Mr. D. McGill, F.Inst.P. (*H.M.I.*), Mr. W. R. Ritchie, A.Inst.P. (*Kirkcaldy High School*) and Mr. B. F. Lord (*Glasgow Academy*).

The Institute and Society accepted a major part of the responsibility for the organization of the seminar. Mr. Clarke, Deputy Secretary, was jointly responsible with Professor Haber-Schaim to O.E.E.C.

Craftsmanship and Draughtsmanship Competition

For several years, a craftsmanship and draughtsmanship competition has been held in connection with the exhibition of Scientific Instruments and Apparatus previously organised by The Physical Society and now known as The Annual Exhibition of The Institute of Physics and The Physical Society. The competition is is still being held in association with the exhibition and it is hoped that the number of entries will increase. Steps are being taken to achieve this and it is possible that from the January 1963 competition onwards the rules will be changed. However, for the next competition the rules will be the same as in the last few years, details of which, and entry forms, may be obtained from The Deputy Secretary at Belgrave Square.

Letters to the Editor

X-rays

Mr. Meredith has described his review of the eighth edition of my book on X-rays as " hostile ". He will not be surprised at receiving a hostile answer.

He complains that attention is paid to ideas and apparatus which are obsolete and cites, as example, the gas tube to which four pages are devoted. Four pages out of a total of thirty which deal with X-ray tubes is not too much when we remember that the gas tube is the example of ionization by collision as compared with the hot cathode tube in the other 26 pages.

Mr. Meredith states that " most of the dosemeters described ceased to be used twenty years ago ". This is clearly untrue. The principles of the electrostatic, electrodynamic and capacitor dosemeters are explained, but of the four instruments which are described, three are of modern capacitor type, and I happen to know that they are in constant demand.

The tables on X-ray percentage depth dose calculation may be out-moded in Mr. Meredith's work, but that does not make them inaccurate or useless.

His next complaint is against the curved Potter Bucky diaphragm. Both the curved and the flat type are described—to explain the principle—but the flat type is quoted as being in more general use. It is true that oscillating and reciprocating grids have been used for a long time but the original principle is the same and the flat type is more frequent.

I stand by and repeat, pace, Mr. Meredith, that in diagnostic radiography " mistakes can be overcome by repeating exposures without risk of doing harm ". To repeat a massive therapeutic dose because something has gone wrong with positioning, etc., would be fraught with danger but to make a second diagnostic exposure is not.

The table based on a permissible dose of 100 r in three weeks was due to Drs. Braun, Hase and Küstner—and was published in Professor Liechti's book on X-ray Physics. In a recent second edition of this book the permissible dose has been halved—and with it the numbers of radiographs which may be taken. Probably the figure is still less by now because permissible doses seem to be moving steadily downwards. But the dose on which the table is based is mentioned and this makes easy the conversion of the permitted number of films to any new dose.

Mr. Meredith concludes by saying that this book which was first published thirty-eight years ago and has with much alteration and modernization now arrived at an eighth edition contains " too many dangerous statements and errors of fact for it to be recommended ". The samples which he gives and which are mentioned above do not enhance his reputation as a fair-minded and unbiased critic.

W. E. Schall (*F.Inst.P.*).
2 Hillcroft Avenue, Purley.

The reviewer comments as follows:

Opinions will always differ on the amount of space that should be given, in any book, to historic apparatus, and it is unlikely that Mr. Schall and I will be reconciled by further discussion. However, I must point out of the twenty-six pages said to be devoted to the hot cathode tube, nearly ten are used in describing such diverse items as valve and metal rectifiers, cables and the pin hole camera, whilst the modern dosemeters are illustrated rather than described.

I agree that being outmoded for my work does not in itself make information useless or inaccurate. Unfortunately, the percentage depth dose tables to which I took exception are all of these. They are for zinc filtration which is seldom, if ever, used and the cited values, when compared with relevant modern data (such as has been published in recent supplements of the *British Journal of Radiology*) show differences of as much as 35 per cent.

The present view on radiography is well summarized in the opening sentence of the Recommendations of the Adrian Committee on " Radiological Hazards to Patients " which runs " There should be clear-cut clinical indications before any X-ray examination is undertaken . . . " In other words the advantage to the patient must be weighed against possible hazard for every radiograph, be it the first, second or twenty-second. In such a context a laid-down table of permissible numbers of radiographs obviously has no meaning. It is also surprising that Mr. Schall should so lightly regard repeated radiographs when, *à propos* the radiation worker, he writes in the last sentence of the penultimate paragraph of the book " And so we might

The Institute and Society is arranging
a Symposium on

The physics of graphite-moderated reactors

to be held in
Bournemouth
from
April 4 – 7, 1962

Session subjects will be as follows:

Present status of lattice physics

Performance characteristics of magnox reactors

Kinetics of magnox reactors

Commissioning and operation of magnox reactors

Enquiries regarding the program should be addressed to the Organizing Secretary, Mr. M. L. Owens, Central Electricity Generating Board, Friars House, 157-188 Blackfriars Road, London, S.E.1.

Some residential accommodation will be available. Further details and application forms will be obtainable early in the New Year from the Administration Assistant of the Institute and Society.

expect that even the smallest dose is fraught with danger"!

In some ways a book review is like an iceberg: because of space limitation many facts upon which statements are based will normally remain hidden. In view of Mr. Schall's final paragraph, however, I consulted the notes made whilst reading the book and found records of more than fifty errors or confusing statements. These range from the presumable misprint on page 300 where the permissible weekly dose for non-radiation workers is given as 30 rads, through the statements on pages 152 and 153 that Compton scattering leads to a reduction in wavelength, or the definition of the unit of a.c. power as the kVA (page 307), to fundamental errors such as the oft repeated allegation that short wavelength X-rays are more readily scattered than longer ones. Other examples could be given but perhaps these will suffice to show that my strictures were more fair-minded than Mr. Schall believes.

W. J. MEREDITH (*F.Inst.P.*).
Christie Hospital and Holt Radium Institute,
Manchester.

"Home-made" apparatus in schools

We recently held a course on Practical Physics for Teachers, one of the main purposes of which was to provide facilities for those attending to construct simple pieces of apparatus to take back to their schools. Although the course was a great success in other ways, this aim was frustrated in the case of about half those attending because they were unable to get permission from their Local Authorities to spend the comparatively trivial amounts required to purchase the materials needed.

We feel that it is highly desirable that all teachers, whatever the grade of their school, should be encouraged as actively as possible to make things for themselves. Besides leading to very good value for money in the actual hardware constructed (which can often be an order of magnitude cheaper than similar items from commercial sources), the exercise is likely to be highly educative for both teachers and pupils. Certainly there should be no financial barriers in the way, nor should teachers be expected to dip into their own pockets, as the very keen often do. Surely every science teacher should be entitled to spend up to £10 or £15 a year at his own discretion, with no questions asked, other than production of receipts ?

We gather that educationists (certainly Her Majesty's Inspectors) are in agreement with this point of view, but that Public Auditors are sometimes unwilling to sanction expenditure of this type. Can the Institute and Society, or any of its members, help to remedy this state of affairs ? A circular from the Ministry of Education to all Local Authorities might do the trick.

Another idea which might encourage the "do-it-yourself" approach would be for Local Authorities to arrange for central workshop facilities at a suitable school or technical college for use by teachers whose own schools do not possess them.

R. D. HARRISON (*A.Inst.P.*)
N. THORLEY (*F.Inst.P.*)
University of Durham,
Joseph Cowen House,
153 Barras Bridge, Newcastle upon Tyne, 1.

X-RAY ANALYSIS GROUP

AUTUMN CONFERENCE
on
IMPERFECTIONS IN CRYSTALS
November 17 and 18, 1961
at
The Institution of Mechanical Engineers, London

Session subjects will be as follows:

The nature of crystal imperfections and of associated diffraction effects.

Experimental methods for studying imperfections. Effects on physical properties.

Included in the invited speakers will be Dr. P. B. Hirsch, F.Inst.P., of the University of Cambridge, and Professor F. C. Frank, O.B.E., F.Inst.P., F.R.S., of the University of Bristol.

Enquiries regarding the program should be addressed to the Honorary Conference Secretary, Dr. G. S. Parry, A.Inst.P., Department of Chemical Engineering, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

Registration is necessary. Further particulars and application forms may be obtained from the Administration Assistant of the Institute and Society.

The Institute and Society is arranging a Symposium on

HIGH ENERGY NUCLEAR PHYSICS

to be held in

The Physics Department of Imperial College of Science & Technology

from

March 26-27, 1962

Several review lectures on both theoretical and experimental topics in high-energy nuclear physics will be included in the program. A limited time will be devoted to short communications. Authors of short papers who would like to be included in the program should send abstracts of their work to Professor C. C. Butler, Physics Dept., Imperial College, London, S.W.7, by January 1, 1962.

It is unlikely that residential accommodation will be available at the College, consequently, intending participants are advised to seek hotel accommodation in good time.

Further details may be obtained from the Administration Assistant of the Institute and Society, during December, 1961.

Reviews of Books

QUANTUM MECHANICS

By J. L. Powell and Bernd Crasemann

Massachusetts and London: Addison-Wesley Publishing Co. Inc. Pp. x+495. Price 74s.

This is a straightforward account of the non-relativistic theory, on more or less conventional lines. It is difficult to think of any important topic that has not been included, or contrariwise, of any unimportant topic that ought to have been omitted. The writing is clear and sober, the mathematical manipulations are set out at length, and there are always excellent physical interpretations of the formulae once they have been proved.

Whose shelf should it grace? Not, I guess, ordinary physics undergraduates, who would find it slightly too formal. But it would make an excellent set book for an undergraduate or postgraduate course in applied mathematics or theoretical physics. Looking at its size and thinking also of all the classical mechanics, statistical mechanics, field theory, and, just ordinary physics that a modern theoretical physicist is expected to know one wonders how one can teach it all in a degree course that is no longer than it was in the days of our fathers that begat us. At least the existence of careful, thorough books like this, with its lucid exposition of the theory and numerous examples on which to practise, means that conscientious students can, in the end, get it up for themselves if they have to.

J. M. Ziman.

INTRODUCTION TO ELEMENTARY PARTICLE PHYSICS

By R. E. Marshak and E. C. G. Sudarshan

New York and London: Interscience Publishers Ltd. Pp. viii+231. Price: Cloth 34s.; Paper 19s.

The physics of elementary particles began to emerge distinctly from the general field of nuclear studies with the discovery of the positron. The subject gained stature with the subsequent discovery of the π and μ mesons and there are now at least 30 particles, mostly unstable, which are classified as elementary. Experimentally the study of these particles and their interactions has become notably distinct from investigations of nuclear structure; it is the province of the high energy physicist and the cosmic ray physicist whose machines and techniques often differ radically from those of the nuclear spectroscopist. Theoretically, too, fundamental particles demand special consideration. The non-relativistic wave equation is no longer adequate even for heavy particles and the Dirac equations are satisfactory only for particles of spin $\frac{1}{2}$ which have no marked "anomalous" behaviour. Theoretical high energy physics has become essentially the theory of fields, with which the elementary particles are associated as quanta, and the properties of these fields under coordinate transformations must account for the observable behaviour of the particles that they represent. The discussion of this type of representation is the subject of this book.

In the preface, it is stated that the book is intended for "the non-expert in theoretical high energy physics, the graduate student, the experimental high energy physicist and all those who wish to familiarize themselves with some of the more permanent features of our present day knowledge concerning the subject". The distinguished authors thereby pay the experimentalist the compliment of assuming that he is either familiar with relativistic quantum mechanics, or willing to become so, for despite its clarity this is not an easy book and demands a considerable apprenticeship for full appreciation. Nevertheless, the non-expert may glean frequent flashes of understanding even by a somewhat cursory reading, and he will undoubtedly find himself stimulated to further thought and study.

Chapter 1 (Introductory Discussion) lists the particles and their observable properties and sets up the familiar photon, lepton, meson and baryon classification, within which the properties of charge and strangeness differentiate the various particles and regulate their decay. The conservation laws and the types of interaction between fundamental particles are also introduced. Chapter 2 considers the problem of the quantum mechanical description of an elementary particle, and shows how the assumed properties of space-time, as represented by relativity and rotation invariance, lead to a classification of particles in terms of mass and spin. The particular cases of physical objects described by the wave equations of Klein-Gordon (spin zero), Dirac (spin $\frac{1}{2}$, finite mass), Weyl (spin $\frac{1}{2}$, zero mass) and Maxwell (spin 1, zero mass) are treated in some detail. The photon and neutrino are thereby considered in parallel with particles of finite mass. The properties of the particles, and their associated fields, under space and time inversion and particle conjugation are discussed and the origin of the concept of intrinsic parity in each of these transformations is demonstrated. It may interest many an experimental physicist to know why the intrinsic space parity of the photons with which he is so familiar is negative. This chapter is the key to the whole book, and it may perhaps be questioned whether it is an adequate one. The reader who is expert in field theory will not need it, and the novice will find it difficult.

In Chapter 3 the authors consider the selection rules for interactions between elementary particles. This involves a somewhat difficult discussion of the interaction between two quantized fields, but illustrative experimental material appears at appropriate points. The significance of the "parity" experiments in the strong, weak and electromagnetic interactions is indicated. Particle conjugation for the electromagnetic interaction is illustrated by the decay schemes of positronium (observable), muonium (perhaps observable), and protonium (unlikely to be observable). For time inversion, experiments on the polarization-asymmetry equality, and on recoil in β decay are discussed. These considerations lead up to a proof of the celebrated CPT theorem, valid for all relativistically invariant theories.

In Chapter 4 there is a survey of the additive conservation laws, which state that for a system of particles and

antiparticles the charge number, baryon number and lepton number are constants of motion. To these may be added, except for weak interactions, the strangeness number, and each conservation implies the invariance of the Hamiltonian of the system with respect to some transformation. Experimental tests of these laws are based on quantitative estimates of the stability of the electron and proton against decay into lighter particles, and on the lifetime of nuclei against double β decay. The question of the equality of magnitude of the charge of the proton and electron is a different one, connected with the conservation laws of electrodynamics.

The last chapter of this enquiring book is devoted to isotopic spin. A survey of the elementary particles shows that the particles which differ only in charge number differ less in mass than those which differ in baryon, lepton or strangeness number. This, together with well known experimental results on pion-nucleon scattering suggests the charge independence of strong interactions, which is described formally by conservation of the isospin vector. The connection between the third component of this quantity and the charge conservation discussed earlier is obvious, but more subtle connections between charge, spin and strangeness now begin to emerge from a survey of the particle properties. These are summarized in a well-known formula due to Gell-Mann and Nishijima, which is here extended also to include lepton number. The isotopic spin of the leptons is a matter which has long been unclear to the average experimentalist. The consequences of isospin conservation for the strong reactions of the fundamental particles are fully stated and relations between cross sections which may be experimentally tested are derived. The book concludes by pointing out that despite all unifying principles it still seems necessary to invoke at least six fields to describe the symmetry properties of the baryons and leptons.

Dr. Marshak and Dr. Sudarshan (whose name appears incorrectly on the cover) have written a tantalizing treatise. The physicist who is used to model calculations may well complain that no " numbers " are produced. He may also wonder how it is possible to give an adequate treatment of elementary particle properties without including much more discussion of their mutual scattering. Despite this he cannot fail to admire the logical way in which predictions of observable behaviour are made from very general principles. The authors write with authority; they move with vision and certainty through many obscure areas. Under their guidance the experimentalist, if he is willing to sustain his effort, may in the end feel that he has reached a partial understanding of some of the more recondite laws of nature. Even if he fails to attain to this end, he should at least admit to a better appreciation of the meaning of many of his experiments.

W. E. Burcham.

HYDRODYNAMICS. Revised Edition
By Garrett Birkhoff
Princeton: Princeton University Press. London: Oxford University Press. Pp. xi+184. Price 42s.

This second edition, revised and enlarged, is published ten years after the original. It would be unthinkable that this book—unique in its approach—should be allowed to go out of print and if for no other reason than this the appearance of the second edition is to be warmly welcomed.

The question the reviewer has to ask is how successful has been the revision. Basically, as the author says : " The overall organization of the material follows closely that of the first edition. It has however been carefully revised in detail and a number of interesting new developments of the past decade have been added ". One has only to observe that included amongst those specially thanked for suggestions are the names of Goldstein, de Fériet, Hayes and Levi to see the interest and appreciation Birkhoff always stimulates amongst fluid dynamicists and to guarantee also the substance of at least some of the revisions.

One should say at once that where the basic material has been revised improvements in presentation and format have taken place. The first chapter of the original edition " Hydrodynamical Paradoxes " has been split into two—" Paradoxes of Non-Viscous Flow " and " Paradoxes of Viscous Flow ". The second chapter of the original headed " Recent Progress in Free Boundary Theory " now becomes " Jets, Wakes and Cavities " and the remaining three chapters of the revised edition " Modeling and Dimensional Analysis ", " Groups and Fluid Mechanics " and " Added Mass " were, if I may be forgiven a slight pun in relation to the latter, virtually included under these heads in the original, though there has naturally been some change in content. [The dust jacket includes the rather misleading statement that a chapter on turbulence has been added; this is not so, for although the material on turbulence has been increased in the revised edition it is still very limited as is only reasonable in a book of this nature].

As in the original, one might take issue with the repeated use of " paradox " defined as " apparent inconsistencies between experimental facts and plausible arguments ", in that in many of the " paradoxes " discussed the arguments can no longer be regarded as plausible. This is, however, a matter of taste and upbringing met, it must be admitted, to some extent by splitting the original first chapter into two. (In passing it is worth pointing out that a misprint occurs in the discussion of the Cisotti paradox on p. 15. In Fig. 2b the pressure is finite at the trailing edge but infinite at the leading edge and the finite force stems from this latter point).

In detail, it is a matter for some doubt whether the revision has taken enough account of the work that has been done during the past ten years but the author might well reply that he had to draw the line somewhere if the character of the book is not to be altered. The fact remains that one might reasonably have expected for instance some reference to the work of Lin and Stuart and their co-workers at the top of p. 38, some elaboration of the application of the ideas of uniformly valid approximations and singular perturbations to Oseen's equation on p. 45 and to the boundary layer equations on pp. 40 and 110, and some mention, at least, of Goldstein's work on the leading edge singularity on p. 40.

Nevertheless these are small criticisms and in no way detract from the overall value of the work which in

my view centres for its importance around the chapters on modeling and dimensional analysis and on groups and fluid mechanics and for which the other chapters may be regarded as forming a background, albeit a most stimulating one. In short it is a book which is thoroughly to be recommended.

L. HOWARTH.

PROTECTION AGAINST RADIATION

By John D. Abbatt, J. R. A. Lakey and D. J. Mathias

London: Cassell & Co. Ltd. Pp. viii + 235. Price 25s.

One of the main tasks facing an author, who writes on a technical subject for the non-specialist, is simplification without sacrifice of accuracy. At least as far as physical topics are concerned, the present authors cannot be said to have succeeded in this task. The text abounds in imperfections of various kinds. They may be grouped under various headings, as the following examples indicate:

Curiosities:

p. 4 " Radiation is so called because it radiates."

p. 220 " Bremsstrahlung: The electromagnetic radiation which results from a radioactive collision."

Incorrect statements:

p. 20: " Each series has about 30 members, the final isotope being stable." Tables on pp. 44-48 show that none of the series has more than 18 members.

p. 38 " 10,000/8 = 625."

p. 70 " The synchrotron is an apparatus which is used to increase the energy of particles already accelerated in one of the other machines."

p. 71 Table 19 indicates that electrons can be accelerated in a cyclotron or synchocyclotron.

p. 70 " Van de Graaf " " Cockroft and Walton."

p. 38 and p. 86 Two different definitions of the curie.

Half truths:

p. 19 " . . . the observed atomic weight is never a whole number but is the average of whole numbers possible."

p. 20 In radioactivity " . . . the nucleus emits one or more of its nucleons."

p. 27 " Gamma rays . . . are frequently absorbed by electrons."

p. 100 An anti-coincidence array with guard tubes— " these are arranged so as to switch off the counter when they detect a cosmic ray."

The medical aspects of the subject are handled much more competently even if the advice given is scarcely specific enough for a practical handbook. On the important subject of blood counts the authors are unwilling to commit themselves.

p. 78 " The main dispute as to the value of the blood count now lies round the question of whether or not it may be regarded as a prognostic indicator. This is not the place to discuss this controversy and no attempt will be made to do so."

The final sentence in the main text, p. 208 (on the genetic effects of radiation) reads—" The mutant result of radiation damage may, however, need to be treated and, for example, mental deficiency will require psychiatric treatment."

J. M. VALENTINE.

THE COLLECTED WORKS OF IRVING LANGMUIR

VOLUME 4 — ELECTRICAL DISCHARGE

Edited by C. Guy Suits

Oxford: Pergamon Press Ltd. Pp. xxii + 409. Price 100s.

It is beside the point to discuss the value of publishing the collected papers of even the greatest scientists when professionals would almost invariably have easy access to the original contributions in the journals. The fact is that Langmuir's collected works are being published in twelve volumes, of which two volumes are devoted to electrical discharge phenomena, i.e. volumes 4 and 5. Of course Langmuir's work in the latter and other fields was quite outstanding and the scope of his labours is almost frightening. It is interesting to notice that nuclear physics apparently passed him by, though he lived and worked actively through its period of springtime flowering.

Dr. Suits' foreword is intensely interesting and naturally somewhat personal so it is permissible to disagree with him on certain points. Thus, Suits suggests that it would be difficult to find a common denominator except curiosity in much of Langmuir's work, but I must differ because nearly all of it dealt with surface physics, from his early experiments on chemical reactions (dissociation and clean-up phenomena, etc.) through his remarkable work on thermionic emission and discharge probe techniques to his much later work (c. 1950) on cloud nucleation. The connecting thread is very clear, binding nearly 50 years of astonishing activity, so much of it still of topical importance. To give examples, in the field of discharge physics Langmuir's work on probes has increased considerably in interest in recent years and current research on thermionic devices for direct conversion of thermal to electrical energy also owes a great deal to him.

Dr. Cobine's introduction to this volume is also of great interest. This is the kind of contribution that could well be expanded, using Langmuir's notebooks which are mentioned in the present volume, into a biography and it touches on many personal matters. Langmuir was, for example, the first great industrial scientist, a fact to which both Suits and Cobine refer in various ways. This aspect alone of Langmuir's life provides much food for thought.

The present volume includes papers, several of them world classics, on positive column effects and probe experiments. There are several review papers which must, of course, be included in any comprehensive collection of Langmuir's work but which have naturally now lost much of their interest, but their clarity and mastery of detail should serve as models to us.

J. D. CRAGGS.

OPTICAL MICROSCOPE TECHNIQUE

By D. Birchon

London: George Newnes Ltd. Pp. x + 274. Price 60s.

In spite of the wide use made of the optical microscope in these days, there has been a conspicuous lack of good modern books on the principles and applications of the instrument. In their " *Practical Science Books* " series, Newnes now offer a manual which should fill this gap

for some time to come. A broad, practical approach is evident throughout the text and the author explains in some detail what apparatus is available for particular purposes and by whom it is made. He steers a courageous and helpful course between the Scylla of cataloguing the equipment of one maker after the other and the Charybdis of being so impartial as not to mention names at all.

The first chapter sets out the principles of microscopy and explains the functions of the different parts of the optical system, including a comprehensive table of the characteristics of typical objectives. Chapter two describes the various types of equipment for microscopy, including hot stages, lighting sources and filters. The next two chapters deal with the operation and care of the microscope and with techniques of illumination and observation, followed by two chapters on the preparation of specimens for transmission and reflection microscopy respectively, and a final chapter on photography. The author's special experience as a metallurgist has resulted in a fuller treatment of reflection techniques than is usual in books on microscopy. Lists of references, both to original papers and to longer works, are given at the end of each chapter. Altogether this handbook bids fair to fill the need for a reliable guide to microscopy for the working scientist who wants to get the best out of his instrument—and it has to be said that no other precision instrument is so badly handled as the optical microscope in most laboratories.

V. E. Cosslett.

PRINTED CIRCUITS. THEIR DESIGN AND APPLICATION

By J. M. C. Dukes

London: Macdonald & Co. (Publishers) Ltd. Pp. xii + 228. Price 40s.

" Printed circuits ", of course, is a misnomer for the kinds of mechanized assembly and wiring processes which are used in the contemporary manufacture of electronic equipment such as broadcast receivers, computers, satellites, and so on. Perhaps it is not widely appreciated that such processes may be economic for quite small quantities of equipment, and physicists who require as little as ten consistent, small and easily handled duplicates of an electronic circuit could profitable consult this book. Nor are the fundamental concepts of printed circuits as new as is popularly supposed. In 1903 a patent was granted to Hansen which included a reference to the electrical and mechanical deposition of conductors, and indeed most of the basic ideas were published by 1930. Nevertheless, much industrial secrecy still veils the details of the processes used in our radio industry and the reader will soon discover that this book is written, not for the production line engineer, but for the circuit and equipment designer.

It is essentially an engineering handbook with many tables and underived formulae but—commendably—adequate references. The first quarter of the book covers the broad outlines of the main manufacturing processes, including dip soldering and component insertion. The remainder of the book deals with the detailed design of the printed board and printed components, including chapters on materials and strip transmission lines. Mr. Duke's presentation is concise and clear, although the book would be the better for a uniform use of its symbols. In a text concerned with electronic circuits and which could be used as a reference manual, it is irritating, and sometimes confusing, for instance, to find that R is used to represent both resistance and the radius of conductors, and that c serves for the velocity of light, the thickness of a bar conductor, and the radical depth of winding on a spiral coil. This may account for some minor misprints, such as that in equation 36 on page 145 where a is used in the formula but the diameter of the wire is given two lines earlier as $2R$. Again, the optimum shape factor for maximum Q of a flat coil has been inverted on page 130.

But these are small criticisms of a book with much practical, succinct, information for those who deal professionally with electronic circuits: it adds a useful title to the meagre and generally unsatisfactory literature on the subject.

G. B. Townsend.

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS, VOLUME XIV

Edited by L. Marton

New York and London: Academic Press Inc. Pp. x + 341. Price $11.00

This latest edition of *Advances in Electronics* includes six survey papers entitled The Electron as a Chemical Entity, Problems of Photoconductivity, Strong-Focusing Lenses, Hydrogen Thyratrons, Cerenkov Radiation at Microwave Frequencies, and High-Power Axial-Beam Tubes. More than one-third of the book is given to Strong-Focusing Lenses, by which is meant electron lenses consisting of 4 poles (or electrodes) arranged like the 4 poles of the stator of a d.c. machine and providing a magnetic (or electric) field which has constant radial gradient $\partial H/\partial r$ (or $\partial E/\partial r$). There is a full survey of the theory and practice of such quadrupole lenses. The first paper, with its intriguing title, is restricted to the study of the effects of imperfections and impurities on conduction electrons and holes in semiconductors. After a theoretical section experimental techniques are described and results are given for germanium, silicon and zinc oxide with a variety of impurities. In the case of zinc oxide consideration is given to effects of various imperfections in chemically pure crystals. The last paper is concerned with klystrons and travelling-wave tubes. The titles indicate the nature of the remaining papers. These reviews appear to be up to the standard set in previous volumes in this series.

M. R. Gavin.

THE DYNAMICAL THEORY OF SOUND

By Horace Lamb

New York: Dover Publications, Inc. London: Constable & Co. Pp. xiii + 307. Price $1.50.

This edition has withstood the passage of thirty-five years remarkably well. In these days we are much concerned with mathematical models and the subtle art of approximation. The following quotation shows how important Lamb regards these aspects of applied mathematics.

" There are many reasons why, from the physical point of view, we may be content with an approximate solution of the problem. Leaving aside such questions as the resistance of the air and the yielding of the supports at the ends of the string, we have still to remember that in substituting a mathematical line of matter, capable only of exerting tension, we have considerably over-idealized the circumstances. In the higher normal modes, at all events, the imperfect flexibility, and the uncertainty as to the true nature of the terminal conditions, render this representation somewhat inadequate, so that a solution which professes to determine these modes accurately is open to the criticism that it attempts too much. Again, the assumed initial form in which two straight pieces meet at a point, is one which can only be approximately realized: if we go too far in this direction we should produce a permanent bend, or kink, in an actual wire ".

The book is a comprehensive mathematical treatment of the physical aspects of sound, including the theory of vibrations and the equations of motion of strings, bars, membranes, pipes and resonators. There are chapters on plane, spherical and simple harmonic waves. The final chapter is about physiological acoustics. All the fundamental differential equations are constructed from the physical conditions and solutions obtained. Necessary mathematical topics such as Fourier analysis and elements of vector analysis are dealt with *en route*. The book can be recommended to students as a model of the art of combining the mathematics and physics of a problem in one exposition.

J. CRANK.

News of Members

FELLOWS OF THE INSTITUTE OF PHYSICS

R. Beeching has now taken up his appointment as Chairman of the British Transport Commission.

O. Blüth is now Professor of Physics in Vanderbilt University, Nashville, Tennessee, U.S.A.

R. I. B. Cooper has been appointed Head of the Department of Science and Technology at Cambridgeshire College of Arts and Technology.

J. A. Clegg has been appointed Professor of Physics in the University College of Ibadan, Nigeria.

J. Darbyshire is visiting Professor of Oceanography at the University of Cape Town for one year.

K. Deutsch is Head of the Department of Electronmicroscopy in the University of Greifswald, East Germany.

J. Lamb is Professor of Electrical Engineering in the University of Glasgow.

Sir Bernard Lovell is the first recipient of the Daniel and Florence Guggenheim International Astronautics Award, which carries a prize of one thousand dollars for outstanding contributions to the progress of astronautics.

H. L. Penman has been elected President of the Royal Meteorological Society.

D. Rogers has been appointed Reader in Chemical Crystallography in the Imperial College of Science and Technology, London.

L. R. G. Treloar has been awarded the Colwyn Medal of the Institution of The Rubber Industry.

ASSOCIATES OF THE INSTITUTE OF PHYSICS

H. S. Caplan is a Research Associate at the University of Toronto.

P. J. Coppen has joined Transitron Electronic Corporation, Massachusetts, U.S.A.

D. Dasgupta is Senior Mineralogist of the Geological Survey of India.

P. L. Degen is Chief Radiologist with Palrier X-Ray Service, London.

W. K. Griffiths is an Assistant Lecturer in the Physics Department of the University of Leeds.

R. M. Hill has been appointed to an I.C.I. Research Fellowship at the Clarendon Laboratory, Oxford.

W. R. Hogg is now at C.E.R.N. in Geneva with a C.E.R.N. Fellowship.

J. W. King has joined the Radio Research Station, Slough, as a Senior Research Officer.

J. R. Leach has been appointed a Director of Sir George Godfrey and Partners Ltd., Hanworth, Middlesex, and retains his post as Chief Engineer.

M. C. Lovell has been appointed Senior Lecturer in Physics at the Royal Military College of Science, Shrivenham.

F. Luckman has been appointed Head Master of Douglas High School for Boys from January 1 next.

G. V. Marr is now a Senior Research Associate in the Physics Department of the University of Reading.

R. G. Martin has joined the staff of Dartford Grammar School.

G. G. Matthews is a Lecturer in Physics at the Rutherford College of Technology, Newcastle upon Tyne.

G. G. Miller is a Senior Research Officer of the Cotton Silk and Man-Made Fibres Research Association, Shirley Institute, Manchester.

B. A. M. Moon is a Senior Lecturer in Mathematics in the University of Canterbury, New Zealand.

E. A. Ryder has joined the Central Electricity Generating Board as an Assistant Engineer in the Nuclear Plant Design Branch.

R. E. Seaman is a Senior Engineer with J. Langham Thompson Ltd.

N. H. Saunders has been appointed Lecturer in Physics at the University College, Swansea.

H. W. Sexton has been promoted to Principal Scientific Officer in the Armament Research and Development Establishment of the War Office.

C. Singh has been appointed Lecturer in Physics in the University of Malaya, Kuala Lumpur.

M. Thomas has joined the British Oxygen Company as Fuels Officer of the Technical Division.

A. J. F. Trott is a Physicist with the U.K. Atomic Energy Authority at Risley.

J. D. Weston has been appointed Professor of Pure Mathematics in the University College of Swansea.

GRADUATES OF THE INSTITUTE OF PHYSICS

B. J. Clark is a Physicist with Unicam Instruments Ltd., Cambridge.

B. Crawford has been appointed an Assistant Lecturer in Physics at Consett Technical College.

J. Davies is a Research Physicist with the Water Research Association at Medmenham, Bucks.

H. Eames is a Lecturer at Whitehaven College of Further Education.

D. B. Gilding is Deputy Head of Research with Yorkshire Imperial Metals, Leeds.

R. A. Giles is an Assistant Lecturer at King's College, London.

K. W. Hayes has been appointed Works Manager of Bernard Wardle (Everflow) Ltd., Caernavon.

A. Higham has joined the Plessey Co., Ltd.

P. J. Hood is a Geophysicist in the Canadian Department of Mines and Technical Survey, Ottawa.

J. Houghton is a Section Leader at the A.E.I. Research Laboratory, Harlow, Essex.

W. J. Ince is now a Staff Member of the Lincoln Laboratory, Massachusetts Institute of Technology.

E. J. M. Kendall is a Lecturer in Applied Physics at Hendon Technical College.

D. J. Lesford is a Scientific Officer with the Royal Naval Scientific Service.

C. H. Panter is on the staff of the John Legott Grammar School, Scunthorpe.

J. A. Rees is on the staff of the Australian National University at Canberra.

B. Robinson is an Assistant Lecturer in Physics at Nottingham and District Technical College.

J. T. Ruben has joined the C.A.V. Research Laboratory.

Miss B. Sherborne is now on the staff of Crown Woods School, London.

K. N. R. Taylor is a Lecturer in Physics in the University of Durham.

D. L. Watkins has been appointed an Assistant Lecturer at the Technical College of Monmouthshire, Crosskeys, Mon.

M. Wells is a Lecturer in the University of Leeds Electronic Computing Laboratory.

Forthcoming Institute and Society Meetings

October 16 at 7.00 p.m. AT MANCHESTER. Manchester and District Branch.
The Mössbauer Effect by Professor H. E. Hall (*University of Manchester*). At The University.

October 18 at 6.30 p.m. AT BIRMINGHAM. Midland Branch.
BRANCH ANNUAL GENERAL MEETING followed by the Chairman's Address at 7.00 p.m. **Musical scales—their characteristics and appreciation** by Mr. M. Milbourn, F.Inst.P. (*Imperial Chemical Industries (Metals Division) Ltd., Birmingham*). At the Engineering Centre.

October 18 at 2.30 p.m. AT LONDON. Low Temperature Group.
Superconductivity—an elementary guide to the theory by Dr. P. W. Anderson (*Bell Telephone Laboratories, Inc.*) and **Superconductivity—some aspects of work with thin films** by Dr. J. M. Lock (*Royal Radar Establishment, Malvern*). At Headquarters.

October 20. South Wales Branch.
The meeting arranged for October 20 has been transferred to November 24.

October 24 at 2.30 p.m. AT LONDON. Stress Analysis Group.
HALF-DAY MEETING on **The nature of stress raisers.** At Headquarters.
Registration is necessary.

October 24 at 7.15 p.m. AT GLASGOW. Scottish Branch **The cocktail party problem** by Professor E. C. Cherry (*Imperial College of Science and Technology, London*). At The University.

October 25 at 5.30 p.m. AT DURHAM. North Eastern Branch.
The cerebral encoding of optical information by Professor D. M. MacKay, A.Inst.P. (*University College of North Staffordshire, Keele*). At the Science Laboratories.

October 25 at 5.00 p.m. AT HULL. Yorkshire Branch.
Nuclear magnetic resonance in solids by Professor E. R. Andrew, F.Inst.P. (*University College of North Wales, Bangor*). At The University.

October 26 at 6.00 p.m. AT LONDON. London and Home Counties Branch.
The riddle of the lower stratosphere by Dr. A. W. Brewer, A.Inst.P. (*University of Oxford*). At Headquarters.

October 27. AT GLASGOW. Scottish Branch (Solid State Group).
AUTUMN MEETING on **Defects in non-metallic crystals** by Dr. P. Pratt (*Imperial College of Science and Technology, London*) and others. At The University.
Further details will be announced later.

November 3 at 7.00 p.m. AT EXETER. South Western Branch.
The Mössbauer effect by Dr. W. M. Lomer (*Atomic Energy Research Establishment, Harwell*). At The University.

November 8. AT LONDON. Low Temperature Group.
Regenerators. At Headquarters.
Details will be announced later.

November 8 at 7.00 p.m. AT LIVERPOOL. Liverpool and North Wales Branch.
The moon by Professor Z. Kopal (*University of Manchester*). At The University.

November 8 at 2.00 p.m. AT LONDON. Acoustics Group.
HALF-DAY SYMPOSIUM on **The transmission of vibrations through the ground** by Dr. N. Ambraseys (*Imperial College of Science and Technology, London*), Mr. H. Pursey (*National Physical Laboratory, Teddington*), Dr. P. N. S. O'Brien (*British Petroleum Ltd., Sunbury*), Dr. A. Bloch, F.Inst.P. (*General Electric Co. Ltd., Wembley*). At Imperial College.

November 9 at 2.30 p.m. AT LONDON. Optical Group.
Measurements of the refractive indices of optical materials over the range 0.2μ to 5μ by Mr. A. Jackson (*National Physical Laboratory, Teddington*) and **Report on the Paris Conference** (July 1961) **on optical materials** by Dr. K. M. Greenland, F.Inst.P. (*British Scientific Instrument Research Association, Chislehurst, Kent*). At Imperial College.

November 10 at 6.00 p.m. AT NEWPORT. South Wales Branch.
Colour television: principles and practice by Mr. K. Hacking (*British Broadcasting Corporation, London*). At the College of Technology.

November 10 at 2.15 p.m. AT LONDON. Non-Destructive Testing Group.
DISCUSSION MEETING on **The role played by dislocation in determining mechanical properties of materials.** At Headquarters.

November 13 at 6.45 p.m. AT MANCHESTER. Manchester and District Branch jointly with The Society of Instrument Technology.
The role of the physicist in process control by Dr. L. J. R. Postle, A.Inst.P. (*Wool Industries Research Association, Leeds*). At The University.

November 14 at 5.30 p.m. AT LONDON. Electronics Group.
An introduction to electron beam parametric amplifiers by Mr. C. R. Russell (*M. O. Valve Co. Ltd., London*) and Mr. M. C. Davies, Grad.Inst.P., (*Hirst Research Centre, Wembley*). At Headquarters.

November 15 at 6.30 p.m. AT BIRMINGHAM. Midland Branch.
Problems of information and control in relation to eye-movements by Professor R. W. Ditchburn, F.Inst.P. (*University of Reading*). At The University.

November 15 at 5.00 p.m. AT SHEFFIELD. Yorkshire Branch.
Rock magnetism, continental drift and ancient climates by Professor P. M. S. Blackett, F.R.S. (*Imperial College of Science and Technology, London*). At The University.

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

Diffusion in heterogeneous media: lattices of parallelepipeds in a continuous phase. By R. M. Barrer and J. H. Petropoulos.
A treatment has been given of the permeability of a heterogeneous medium consisting of a regular lattice of rectangular parallelepipeds in a continuum. Effects on the permeability due to surface resistances on the upstream and downstream faces of the parallelepipeds have been considered, and also aspects of the role of particle shape and orientation. The treatment provides an approach to the permeability of and fractionation by foam plastic membranes. When the disperse phase has molecular sieve properties, high continuous fractionation factors for appropriate composite membranes and mixtures of diffusants are found to be possible. The treatment is also valid for the thermal or electrical conductivity, permittivity, or magnetic permeability of such a lattice.

Determination of the emissivity, for total radiation of small diameter platinum–10% rhodium wires in the temperature range 600°–1450°C. By D. Bradley and A. G. Entwistle.
The method of measurement of the emissivities is described. Two different lengths of wire, of the same diameter, were electrically heated *in vacuo*. By this procedure the end cooling correction could be eliminated experimentally. From the readings of wire resistance and current the net rate of radiant energy loss from the wire to the surroundings, and hence the wire emissivity could be found.
The values of emissivity are compared with those for platinum wires and also with values calculated from wire resistivity on the basis of electromagnetic theory.

Rapid method for determining v.h.f. dielectric parameters for liquids and solutions using standing wave procedures. By M. G. Corfield, J. Horzelski and A. H. Price.
A rapid method of measuring the dielectric parameters of liquids and solutions in the frequency range 250 to 900 Mc/s is described. The method adopted is a variation of the one due to Roberts and von Hippel, but involves far less mathematical labour. Permittivities may be measured to an accuracy of $\pm 2\%$ and loss tangents to $\pm 1 \times 10^{-4}$ or $\pm 5\%$ (whichever is the greater).

Influence of the electric field on silver and iron whiskers growth. By T. Hoffmann, J. Mazur, J. Niklibore and J. Rafalowicz.
The influence of an electric field on silver and iron whiskers growth obtained by Brenner's method has been studied. There is a marked directional tendency during the growth process; the findings are compared with results of investigation on copper.

Method for the measurement of surface microtopography—experiments with gelatine models. By J. D. Huffington.
The way in which the real area of contact between surfaces varies with load depends for elastic deformation on the surface microtopography. A previously obtained theoretical relation between these factors is tested experimentally by using simple large scale gelatine model surfaces. In this way it should be possible to give a clearer meaning to the interpretation of friction–load curves when these are used to give information about surface microtopography.

Indium antimonide tunnel diodes—a review. By K. F. Hulme.
The small energy gap and effective masses make InSb of interest because the high tunnelling current densities needed for an electronically fast device can be achieved very readily with low doping concentrations. The major disadvantage from the viewpoint of electronic applications would be the need to cool the diode. The ways in which the study of InSb tunnel diodes has contributed to the understanding of the physical processes involved in tunnelling, are described.

Bombardment induced re-emission of ionically pumped inert gas from a glass surface. By L. H. James and G. Carter.
Studies have been made of the release of inert gas, ionically pumped into glass surfaces, by subsequent bombardment with a second ion species. It is found that ion bombardment, up to energies of 1 kev, cannot completely recover sorbed gas. This, and other evidence, leads to the conclusion that gas is released, during ion bombardment, by transfer of sufficient energy to a trapped gas atom, for its desorption, rather than simultaneous release during glass sputtering. Approximate values for gas sputtering coefficients are deduced. It is also concluded that gas is held in superficial trapping sites rather than in a depth distribution into the solid.

Some electromechanical effects on dielectrics. By K. C. Kao.
On the basis of the principle of minimum potential energy, mechanical forces in electrically stressed dielectrics have been derived. These forces are appreciable in strong electric fields. A brief discussion is given with particular reference to their effects on the dielectric breakdown.

Compensating radiometer. By A. R. King.
A radiometer for the measurement of near infra-red radiation in fire research is described. The novel features of the instrument are robustness ability to withstand immersion in flames and the absence of windows.

Recording micro-densitometer employing beta-radiation from a carbon-14 radioisotope source. By R. A. Lloyd.
The variation of wood density through the thickness of the individual growth rings of trees is of interest to those concerned with the growing of trees and the subsequent utilization of the timber. An experimental instrument has been developed in which a finely collimated beam of carbon-14 beta-particles is used to measure the density variations along thin longitudinal sections cut with a microtome from radial core borings obtained from the trunks of standing trees. The response of the instrument is linear for densities up to 0·8 g/cm³ with sections 100 microns thick, and density discontinuities 0·05 mm apart can be resolved. Density changes of 3·5% can be detected, at a speed of traverse of 0·5 mm/minute. The instrument may well be applied to other materials.

Photoelectric processes in calcium oxide coated cathodes. By C. H. B. Mee and F. A. Vick.
The spectral sensitivities of photoelectric emission and photoconductivity in probe diodes containing cathodes coated with calcium oxide have been determined over the range of photon energies from 1·4 to 3·1 ev. The two spectral sensitivities are similar in form, showing a rapid rise below about 2·2 ev, followed by a more gradual increase. Structure at about 2·5 to 2·6 ev is insensitive to the state of thermionic activity of the cathode, and is attributed to the presence of an impurity level at this depth below vacuum potential in the optical energy level scheme. Experiments involving studies of the recovery of photoelectric emission and photoconductivity after oxygen poisoning and of magneto-resistive effects in dark and illuminated conductivity suggest that the greater part of the photoconductivity current is carried by a process of photoelectric emission across the cathode pores. Thermal activation energies have been determined by measurements of the thermionic emission from and the electrical conductivity of the cathodes as functions of temperature.

CONFERENCE REPORT

Thermoelectricity conference, Durham 1961. By B. R. Pamplin.
This report gives a summary of the main features of the papers presented at a Conference held by The Institute of Physics and The Physical Society in the University of Durham on July 10, 11 and 12, 1961.

Current-decay of millisecond duration in thermionic valves (the grid-film effect). By J. Seymour.
Pulsed measurements show that the effect consists of long-time decay nearly completed in 5 ms, and a short-time decay requiring from 10 to 100 μs for completion. It is shown to be due to a parallel R.C combination in series with the control grid, and values of R from 0 to 8000 ohms and of C from 0·08 to 70 $\mu\mu$f have been measured. The value of the resistance is inversely proportional both to the temperature of the grid and to the current flowing to it, and is unaffected by electron bombardment at energies of 400 ev or less. The resistance reduces the initial electron velocity current and can cause cut-off of the anode current in circuits where the grid potential becomes positive with respect to the cathode. Operation of the valve under normal conditions for 1000 hours results in a slight fall in resistance, but under zero current conditions it falls to zero within 48 hours. Examination of the grid side rods by electron diffraction indicates the presence of barium and strontium oxides. These are evaporated from the cathode during valve processing, and are deposited as crystallites about 30 Å in size. A strong indication is obtained that the crystallites are oriented mainly at random in a low resistance film and mainly in preferred orientations in a high resistance film. This is confirmed in patterns obtained from the area of the film causing the current decay in valves with the grid replaced by a solid collector.
The electrical and physical observations are shown to be consistent and are compared with the available information on the oxide-coated cathode.

Measurement of thermal conductivity of semiconductors at high temperatures. By A. D. Stuckes.
A brief description is given of absolute, comparative and ångström methods of measuring thermal conductivity at room temperature and above. Results from various sources on Si, Ge, InSb, InAs and some tellurides are summarized and discussed.

Microwave appraisal of maser crystals. By J. S. Thorp, J. H. Pace and D. F. Sampson.
The potentialities of microwave spectrometer techniques in assessing the purity and crystalline quality of synthetic maser crystals are illustrated by a comparison of the paramagnetic properties of ruby samples grown from the vapour phase and from powder by flame fusion. Typical spectra presented are discussed in relation to complementary chemical and spectrographic analysis and it is shown the information obtained is of direct relevance to the accurate control of methods of crystal growth.

Journal of Scientific Instruments

Metal cell for use in vapour pressure measurements by the effusion method. By S. Blairs, R. A. J. Shelton and R. Unsworth.
Full constructional details are given for an effusion cell in Armco iron, which in conjunction with a calibrated glass spring and cathetometer has been used to measure the vapour pressure over solid ferric chloride in the temperature range 100–200°c. The chief advantage claimed for the cell is that the effusion orifices, in interchangeable push fit end caps, are of the form of true circular knife edged holes with easily determined dimensions.

Continuous recording of suspended solids in effluents. By R. Briggs.
An account is given of a suspended-solids recorder which makes use of the principle of measuring continuously the ratio of the light transmitted by a water sample to that scattered from a beam passing through it, using a single photocell and amplifier. Two light beams, passing at right angles through the sample, are chopped at characteristic frequencies so that the component of photocell output due to transmission may later be separated from that due to scatter. The range of the instrument can be varied between 0–20 p.p.m. and 0–1000 p.p.m. Readings are not affected by variations in incident light, sensitivity of amplifier or photocell, fouling of cell windows, colour of suspended particles or dissolved colour.

Tripping a 1kv single-stage impulse generator. By T. E. Broadbent, and R. Cooper.
A method is described of tripping a single-stage 1kv impulse generator using a beam of light and no direct electrical connection between the tripping circuit and the impulse generator. The method facilitates synchronization of the recording cathode-ray oscilloscope time sweep with the output impulse.

Instrument for the measurement of elastic hysteresis in torsion. By R. Diamond and J. E. Whittle.
The paper describes an instrument capable of measuring the elastic hysteresis of a rod specimen in torsion under static conditions, when the hysteresis strain is only a few parts in 10^6 of the maximum strain. An interferometric strain gauge is employed with specimens approximately 9 in. long by 1/8 in. diameter.

Direct-reading balances for percentage moisture content. By J. G. Downes, B. H. Mackay, L. G. Bellamy and V. D. Burgmann.
This paper describes two types of balance which indicate per cent moisture content directly and in which the initial sample weight may vary within wide limits. They have been designed primarily for measuring the moisture in wool at various stages in processing and for this purpose are used in conjunction with a hot air drying apparatus. The same balances could be used to determine the percentage content of removable components in many other materials. An analysis of the principles of operation of the balances is given and experimental models are described.

Generation of low-frequency sinusoidal voltages of given phase amplitude and frequency by means of a two-integrator loop. By J. C. Earls.
By solving the equation of simple harmonic motion on a d.c. electronic analogue computer, sinusoidal voltages of variable phase, amplitude and frequency can be obtained. Three high-gain d.c. amplifiers are required and these are connected as a two-integrator loop. The frequency is determined by the loop gain and the phase and amplitude by the loop gain and the initial conditions of the integrators.

Distance measurement by means of a light ray modulated at a microwave frequency. By K. D. Froome and R. H. Bradsell.
The paper describes an experimental equipment (known as the 'NPL Microwave Mekometer') using elliptical polarization modulation of a light beam at 9·4 Gc/s (9400 Mc/s) and intended for the accurate measurement of distances of the order of 50 m. The beam is returned from a distant reflector to the modulator at which the ellipticity is either increased or cancelled. A knowledge of the speed of light and the modulation frequency serves for the derivation of the modulation wavelength; the distance from reflector to modulator is then obtained in terms of the number of modulation wavelengths in it.

Safe universal mounting and alignment system for x-ray goniometers. By W. Hughes and C. A. Taylor.
A universal system which permits all the goniometers in a particular x-ray laboratory to be positioned rapidly and simply on any x-ray generator is

described. An integral part of the system is a dummy x-ray tube—an optical system producing a beam of light—which permits the alignment of a goniometer to be carried out in complete safety from radiation. On transferring the goniometer to the x-ray generator no further adjustment is necessary.
The system improves the efficiency of a laboratory in which many workers use the same goniometers and generators. It also improves the safety from radiation, particularly for teaching laboratories in which alignment of goniometers has to be carried out by relatively inexperienced personnel.

Shock-tube β-ray densitometer. By M. McChesney.
A method for measuring the varying density behind a hypersonic shock wave in air using the absorption of β-particles is described. Calculated absorption curves are given for typical β-particle energies over the full range of initial downstream pressures encountered in shock tubes.
The scintillator, photo-multiplier, detector circuit is discussed and an illustrative calculation of source size and accuracy of measurement is given for the case of ^{35}S.

Construction and operation of a simple flame-ionization detector for gas chromatography. By D. J. Morgan.
The construction of a cheap and simple gas chromatograph incorporating a flame-ionization detector is described.

Low-velocity gas–liquid impinger for the continuous estimation of sulphur dioxide and other atmospheric pollutants. By T. Nash.
The instrument records sulphur dioxide conductimetrically in the range 0·01 to 10 parts per million where rapid changes in concentration can be expected but the accuracy required is not more than 1 in 20. Sampling is continuous and cumulative, with a return to initial conditions two or three times an hour. The principle of operation is the removal of a soluble vapour from an air jet impinging on to an unbroken liquid surface. One modification measures light absorption instead of conductivity, permitting the use of colorimetric reagents.

Analysis of error due to edge heat loss in measuring thermal conductivity by the hot plate method. By A. W. Pratt.
An analysis is made of the error due to edge heat loss in the steady-state determination of thermal conductivity using a hot plate as recommended in British Standard 874: 1956, 'Definitions of heat insulating terms and methods of determining thermal conductivity'. The solution obtained applies to a rectangular hot plate with or without a guard ring and takes account of heat exchange at the exposed edges of the test specimen in a more precise way than existing solutions. It is therefore less restricted in its application to practical tests.

Miniature cryostat for measurements on ferromagnetics between 1·6° and 300°K. By W. R. Scott and J. Crangle.
The cryostat requires external supplies of the liquids helium, hydrogen and nitrogen. It operates within a working width of 19 mm at the specimen position, and the vertical height from specimen to top is 20 cm. It is used with the Sucksmith ring balance. Very steady specimen temperatures are possible throughout the range 1·6° to 300°K, and it is economical to operate.

Measurement of rapid temperature changes by thermocouples. By J. A. Sirs.
Measurements have been made of the response time of thermocouples to sudden temperature changes. A simple circuit has been designed to further improve the response time, so that changes occurring within a few milliseconds can be observed with a mechanically robust junction.

Simple form of balance for the rapid measurement of magnetic susceptibilities. By E. V. Smith.
A simple form of magnetic susceptibility balance is described which is capable of giving absolute determinations of susceptibilities of moderate magnitude, with a fair degree of accuracy. It is quite rapid in performance and has the added advantage that it can be used to investigate phenomena where transient changes in overall susceptibility are taking place.

New approach to ultra high vacuum. By J. A. Turner, R. M. Pickard, and G. R. Hoffman.
A conventional vacuum system has been modified to enable a large volume ultra high vacuum to be obtained. A liquid nitrogen trap, situated part way up a tall glass vacuum vessel, isolates the working space from the rest of the system. Thus the trap and the working space, being seal free, may be baked at 425°c. The rest of the system uses demountable indium metal seals and is exhausted by a 9 in. oil diffusion pump with a refrigerated chevron baffle. Baking the vacuum vessel enables a pressure of $1·5 \times 10^{-8}$ torr to be obtained rapidly. With liquid nitrogen circulating and titanium getters fired, an ultimate of $1·5 \times 10^{-9}$ torr is readily achieved.

Vibration isolator for galvanometers. By J. Wilbur-Ham.
The mounting has a damped section for suppressing resonance and an undamped section for attenuating high frequencies. To isolate horizontal vibrations, the platform either hangs by fine wires or rests on thick bi-spherical lenses.

Proceedings of The Physical Society

The Dember and photoelectromagnetic effects in semi-insulating gallium arsenide. By C. M. Hurd.
The Dember and photoelectromagnetic effects have been measured over a temperature range of 140° to 300°K for high resistivity crystals of gallium arsenide. Above 270°K the Dember voltage changes slowly with light intensity but below 270°K a rapid variation is found. This difference in dependence on light intensity is attributed to the onset of the photo-electromagnetic effect. It is concluded that the Dember effect characteristics are modified by carrier trapping at lower temperatures but that to a first approximation the photoelectromagnetic effect is independent of trapping for the conditions obtaining in the experiments.

Growth of cadmium fluoride crystals from the melt. By D. A. Jones and R. V. Jones.
Crystals of cadmium fluoride have been grown from the melt by the Stockbarger process up to 15 cm in diameter and 12 cm in length. Special difficulties are the tendency of the melt to evaporate and also to dissociate, and for a 'crust' to form on the crystal. It is possible to choose an operating pressure (2 mm Hg) such that the undissociated material stays in the crucible while any free cadmium and the dissociation can evaporate, giving a crystal transmitting down to about 2060Å. Furnace details and operating conditions are described and the effect of temperature gradient discussed.

The scintillation properties of cadmium fluoride. By R. V. Jones and J. H. Pollard.
Pure crystals of CdF_2 are found to scintillate with 7·1 millimicroseconds decay time and an efficiency which is low but sufficient for the purpose of high energy spectroscopy. The decay time and the efficiency are temperature dependent; at —178°c the former increases to 120 millimicroseconds and the latter to 14 times its room temperature value. The crystals are optically clear from 2200Å; the scintillation emission band extends from 5000–5800Å. Large crystals have been used to detect cosmic mu mesons and the resolution obtained is in reasonable agreement with the expected value. The short radiation length (1·6 cm) of CdF_2, combined with the fact that large (e.g. 14 cm diameter) crystals can be grown, offers possibilities for high energy gamma-ray spectroscopy, and the fast decay time may allow the investigation of fundamental particle reactions.

Determination of the Fierz interference term from the x-capture/β^+ ratio for the pure Gamow–Teller decay of ^{14}Co. By B. R. Joshi and G. M. Lewis.
A direct determination has been made of the Fierz interference term b for the pure Gamow–Teller decay of ^{14}Co. The K/β^+ ratio has been determined by internal source scintillation counter methods at $4·92 \pm 0·09$. This compares with the recent predicted value of 4·87. Allowing for the variation in the theoretical value due to β^+ and point uncertainty this yields a value for b of $(+0·6 \pm 2·3)\%$. Two interpretations of the result are possible on the basis of two component neutrino theory. If, as is customarily assumed, $C_A = C_{A'}$, $C_T = -C_{T'}$, then b should vanish identically; and the small experimental value for b confirms the exactness of this theory. If alternatively, $C_A = C_{A'}$, $C_T = +C_{T'}$ then the experimental result requires that C_T, $C_{T'}$ be calculably very small.

Secondary electron emission from clean metal surfaces bombarded by fast hydrogen ions. By L. N. Large and W. S. Whitlock.
The secondary electron emission coefficient γ has been measured for clean Au, Pt, Ag, Mo, Cu, Ni, Zr, Ti and C surfaces bombarded with H_3^+, H_2^+ and H^+ ions of energies between 10 and 140 kev. Measurements of γ have been made within the mono-layer adsorption time (~5 min) after flashing of the targets to a high temperature in background pressures of approximately 10^{-9} mm Hg. The measured values of γ intrinsic to clean metal surfaces are relatively low, e.g. $\gamma = 1·5$ for 100 kev protons incident on atomically clean molybdenum. A maximum in the yield curve for protons is found to occur in the velocity range 3×10^8–4×10^8 cm sec^{-1}. The yield for H_3^+ ions is found to be almost twice that for protons at the same velocity and the yield for H_2^+ ions is only about 17% less than that for three protons at the same velocity. For a given ion, γ is found to vary little for the metals studied although the coefficient does increase slowly with atomic number.
A few measurements involving D_3^+ and He^+ ions show that the yield for D_3^+ is exactly the same as that for protons at the same velocity. The yield for He^+ is approximately twice that for protons.
The results are discussed in relation to a theory of secondary electron emission due to Sternglass. Partial agreement is observed.

Space correlation and energy levels in an Einstein solid. By T. Lukes.
It is shown that the space correlation function of any space-dependent atomic property may be used to estimate the degree of order in a solid. The correlation function is evaluated for an Einstein solid and is shown to have both long-range order and short-range order components. The thermal scattering and band structure of an Einstein solid is treated by means of time-dependent perturbation theory on the loose-binding approximation, and it is shown that the scattering matrix is related to the spectrum of the potential, the short-range and long-range components giving rise to thermal scattering and energy gaps respectively.
The width of the gaps is found to decrease exponentially with temperature; for a one-dimensional model of sodium the temperature coefficient is found to be about 10^{-3} per degree. On a Mott-type one-dimensional model of liquid sodium this implies a 20% contraction of all energy gaps on melting.

The ^{7}Li(p, p′) reaction at 150 kev. By D. Newton, A. B. Clegg, G. L. Salmon, P. S. Fisher and K. J. Foley.
Measurements are reported of the inelastic scattering of 150 kev protons from the first excited state of ^{7}Li. The results are compared with other measurements of inelastic scattering from higher states of ^{7}Li and support the identification of the low-lying negative parity states of ^{7}Li as a rotational band in a distorted nucleus. It is remarked that measurements of the polarization of the outgoing proton from inelastic scattering of medium energy protons from 1p-shell nuclei give further support to the identification of rotational bands in these nuclei.

Time lags associated with ultra-high-frequency gas breakdown. By W. A. Prowse, J. R. Rowbotham nd P. G. Monk.
A method of measuring time lags associated with ultra-high-frequency gas breakdown is based on the use of an oscillator giving a long pulse at 183 mc/s. The time zero is fixed by the firing of an auxiliary spark which provides photoelectrons in the gas between the electrodes. Times-to-breakdown are then analysed into a statistical component t_s and a formative component t_f.
In hydrogen, gaps 0·25 cm to 0·60 cm (Rogowski electrodes) at pressures 1 mm to 20 mm Hg were used. Visual examination showed no observable lag: i.e. the lowest field increase from condition of no breakdown moved

the breakdown record to the time zero mark. In air for slightly shorter gaps there was no measurable formative time, but statistical lags up to hundreds of microseconds were observed.
In neon (0·2 to 0·8 cm gaps, pressures up to 161 mm Hg) t_f and t_s were both measurable and were of comparable magnitude. The variation of t_f with applied field was not sensitive to gap width but could be explained by assuming that ionization in this gas was preceded by the formation of metastables. Irradiating the gap with visible Ne light raised the breakdown potential.

A note on the Carr–Purcell method of measuring nuclear magnetic resonance relaxation times. By H. Pursey.
In measuring T_2 by the Carr–Purcell method the number of 180° pulses which can be used in a given sequence is limited by the accumulation of errors in pulse length, which causes a progressive departure of the freely precessing magnetic moments from the equatorial plane. Several methods have been devised to overcome this limitation, but in all cases it is assumed that phase coherence exists between the precessing nuclei and the pulsing radio-frequency field. Under such conditions the errors will accumulate linearly in the orthodox Carr–Purcell experiment, but in fact the order of stability implied in the assumption is unlikely to exist unless special care is taken to obtain it. It has been found experimentally, however, that good Carr–Purcell trains can be obtained in an incoherent system and in the present paper the reasons for this are analysed. It is shown that in such a system the errors add as if they were coplanar vectors of random direction, so that the statistical root mean square value of the error after n pulses is proportion to $\sqrt{n}$. Hence, one would expect to obtain a satisfactory train with up to 10^4 pulses, and it is shown that this is in agreement with observations.

A search for vibrational energy effects in the dissociation of H_2^+ ions by hydrogen gas. By A. C. Riviere and D. R. Sweetman.
The dissociation cross section on interaction with hydrogen gas was measured for H_2^+ ions with energies between 280 and 670 kev and with both high and low vibrational excitation. An increase of 7 ± 5 per cent was found for the cross section for simple dissociation in the case of the more highly vibrationally excited ions. For dissociation into two protons the difference between the cross sections was certainly less.

Characteristic electron energy loss spectra of a number of solid elements. By J. L. Robins.
The characteristic electron energy loss spectra of the elements Ga, In, Tl, As, Se and Te have been obtained using the reflection technique and primary electron energies of 1500 and 800 ev. The results are discussed in conjunction with those for Ge, Sn, Pb, Sb and Bi obtained by Powell in 1960. The spectra of all these elements comprise principally plasma and lowered plasma losses and combinations and multiples of these together with some loses associated with ionization and also, in Se and Te, a loss which is presumably due to an interband transition. The plasma loss peak is found to be narrower where there is agreement between the observed and theoretical plasma loss values and the relationship between these values is discussed. In conclusion, a resumé is given of the results which have been obtained for 33 elements using the same unit of equipment. In the elements other than the transition and noble metals the excitation of plasma type oscillations is the dominant loss mechanism, almost to the exclusion of interband transitions, whilst the latter are of much greater importance in the complex spectra of the transition and noble metals. Ionization is observed in the majority of the elements studied.

Characteristic electron energy loss spectra of some alkali metals and alkaline earths. By J. L. Robins and P. E. Best.
The characteristic electron energy loss spectra of Na, K, Ca and Ba have been obtained using the reflection technique and primary electron energies of 800 and 1500 ev. All of the energy losses observed in these metals can be explained as arising from three types of loss mechanism, namely the excitation of plasma-type oscillations, electronic transitions involving excited states and ionization. Plasma excitation energies of 5·87 and 3·87 ev were observed in Na and K respectively, though the first plasma loss peak in the spectra of these metals was displaced from its expected position. The loss peaks in K, Ca and Ba which are considered to be associated with excited states have been related to previously unexplained series of peaks in Ti, V and Cr, and a peak in Zr. The specific form of the excited state involved cannot be determined from this data alone, but evidence is presented which suggests that an intense broad peak of this nature will occur in the spectra of all the elements which immediately precede or are at the beginning of each of the series of transition metals in the periodic table of elements.

Magnetothermal measurements on gadolinium. By L. F. Bates and A. J. Pacey.
The small heat changes accompanying the magnetization of 99·9% pure gadolinium were measured on a rod specimen. The results are analysed, and the principal magnetization processes are identified. Domain wall movement which occurs in low fields is discussed in the light of a theory by Goodenough, and the coercivity which the theory predicts is found to agree fairly well with experiment. Comparison is made with earlier results for cobalt.

Excitation of helium to the $(1s, 2p)^1P$ and $(1s, 3p)^1P$ states by proton and alpha particle impact. By R. J. Bell.
The distortion approximation is applied to the processes
$$H^+(\text{or } He^{++}) + He(1s^2)^1S \rightarrow H^+(\text{or } He^{++}) + He(1s, 2p)^1P$$
$$H^+(\text{or } He^{++}) + He(1s^2)^1S \rightarrow H^+(\text{or } He^{++}) + He(1s, 3p)^1P$$
cross sections being obtained for incident proton energies, in the range 10 kev to 1000 kev and for incident alpha particle energies in the range 40 kev to 4000 kev. For proton impact the maxima cross sections are found to be $0{\cdot}18\pi a_0^2$ and $0{\cdot}035\pi a_0^2$ at 80 kev and 124 kev respectively, and for alpha-particle impact they are found to be $0{\cdot}61\pi a_0^2$ and $0{\cdot}101\pi a_0^2$ at 511 kev and 935 kev respectively.

The characteristic electron energy loss spectra of some alkali halides. By P. E. Best.
The characteristic electron energy loss spectra of the alkali halides LiF, LiCl, NaF, NaCl, NaBr, NaI, KF, KCl, KBr, KI, RbCl, CaBr and CaI, were measured using primary energies of 800 ev and 1500 ev. In each spectrum a peak due to the excitation of the valence electron plasma oscillation is observed. There is good agreement between this energy loss and the plasma energy $\hbar\omega_p$, calculated assuming that the valence electrons are able to participate in such oscillations. In some of the spectra a loss peak at energy approximately $\hbar\omega_p/\sqrt{2}$ is observed, having intensity characteristics which can be associated with an oscillation of ions. The peaks remain unidentified but appear to be due to a longitudinal plasma oscillation.
Of the other peaks observed, some are thought to be due to ionization of atoms and ions in different levels; the occurrence of a peak for cations heavier than sodium is discussed in terms of an " excited state ", further peaks are attributed to interband transitions, and others go unidentified.
The K x-ray absorption curves for the potassium ion in the potassium halides are reproduced to show that in intensity and energy the x-ray absorption can be represented as being due to the excitation of a K electron to the valence band with simultaneous excitation of some mode of plasma oscillation.

Ion sorption in the presence of sputtering. By G. Carter, J. S. Colligon and J. H. Leck.
A model to describe the sorption of gas during the ion bombardment of solid surfaces has been developed in analytical terms, assuming any general form for the ion penetration probability. It is shown how continuous measurement of the quantity of gas sorbed, up to saturation conditions, can lead to a deduction of the form of the penetration function, and how investigation of the depth distribution at saturation can also lead to the form of this function. It is emphasized that in order to obtain the exact form of the penetration function from the depth distribution, either saturation conditions must be attained or very small quantities of gas must be sorbed.
The theory is also extended to include the case where a surface is continuously replenished rather than eroded by sputtering.
Penetration probability curves are deduced from various experimental studies and are found to be of the form anticipated from the Bohr theory of penetration. Possible modifications to the simple theory are also outlined.

The Lorenz parameter in dilute silver–manganese alloys at liquid helium temperatures. By M. S. R. Chance.
Thermal conductivity data at liquid helium temperatures, on polycrystalline rods of three dilute silver alloys (containing respectively 0·55, 0·32 and 0·14 atomic per cent of manganese in solid solution) in magnetic fields ranging from 0 to 25 kilogauss, have been analysed afresh. The electronic and lattice components of the thermal conductivity are separated by the method of Gruneisen–De Haas. It is inferred that the electronic Lorenz parameter L_e (i) is independent of the magnetic field but varies with the temperature in the liquid helium region, (ii) exhibits a minimum at a temperature which increases with the increase in manganese content, and (iii) is much smaller than the normal ' Sommerfeld ' value, but seems to extrapolate to that value at about 1°K.
This behaviour of L_e is explained on the basis of inelastic scattering of the conduction electrons by the magnetic impurity centres having closely-spaced energy states; for such an inelastic scattering would contribute considerably to the electronic thermal resistivity while making only a small contribution to the electrical resistivity. Further, since such a scattering cannot occur at 0°K, L_e should approach the normal value at the lowest temperatures.

Electrical resistivity and paramagnetic resonance in gadolinium hexaboride. By B. R. Coles, T. Cole, J. Lambe and N. Laurence.
Magnetic susceptibility measurements on GdB_6 have been interpreted in terms of an antiferromagnetic interaction between $4f^7$ ion cores via one conduction electron per gadolinium atom. Electrical resistivity data are presented which show the spin-disorder contribution to be expected on this basis, and a surprisingly large effect ascribed to short-range order above the Néel temperature. An electron spin resonance has also been observed; this has the characteristics to be expected of a $4f^7$ ion in a metallic matrix and cannot be observed in the antiferromagnetic temperature range.

Measurement of transition probabilities in the visible spectra of O I and C I and estimation of vacuum ultra-violet radiation standards. By E. W. Foster.
Previously measured lines λλ 3947, 4368, 5330, 5436 of O I and 4770, 4932, 5040, 5052, 5380 Å of C I have been re-measured using vortex arc methods. The new recommended transition probabilities in $sec^{-1} \times 10^6$ are, for O I, 3·29, 8·57, 19·6, 29·4 and for C I, 9·9, 32, 2·2, 12·6, 10·5 respectively. An axial temperature of 12 436°K is found for a 50 amp, 8mm diameter, water vortex arc. The absolute radiation from this arc is computed for Lyman α and O I λ 1302 Å to be $4{\cdot}88 \times 10^8$ and $7{\cdot}47 \times 10^6$ ergs sec^{-1} cm^{-2} $sterad^{-1}$ $(cm^{-1})^{-1}$ near the line centres respectively.

Energy loss processes in ZETA. By A. Gibson and D. W. Mason.
The energy lost from ZETA discharges, in deuterium and argon by radiation, plasma particles and non-thermal electrons, has been investigated experimentally over a wide range of conditions. Two definite regimes of energy loss have been established. These regimes are determined principally by the pressure at which the machine is operated. At high pressures (5 microns) line radiation from impurities is the dominant loss process and under certain discharge conditions accounts for all the energy fed into the discharge. Theoretical considerations are presented to show that the observed impurity content of 10^{13} atoms per cubic centimetre can account for the radiation loss. At lower pressures (0·5 micron) the energy is lost by particles, firstly by plasma which is not efficiently confined and secondly by fast electrons which are accelerated at the termination of the current pulse and strike the tube walls with about 8 kev of energy.
The results reported are related to energy loss observations made by workers with other stabilized pinch devices.

Spin–lattice relaxation of chromium ions in ruby. By J. C. Gill.
Measurements have been made of the spin–lattice relaxation of single chromium ions and of certain chromium–chromium pairs in ruby. Pairs whose energy levels are split by ' exchange ' interactions equivalent to a few °K relax much more rapidly than the single ions. There is some evidence that the phonons participating in the relaxation have energies equal to certain of the splittings. Modulation of the ' exchange ' interaction by the lattice vibrations provides a possible means of relaxation at low temperatures. In sufficiently concentrated crystals (containing at least 0·21% Cr) a rapid transfer of excitation is observed between the pairs and the single ions. The relaxation via the pairs then accounts in order of magnitude for that of the single ions. The coupling to the observed pairs is too weak to explain the concentration-dependent relaxation of the single ions in more dilute crystals.

Paramagnetic resonance of manganese. By T. P. P. Hall, W. Hayes and F. I. B. Williams.

The paramagnetic resonance spectrum of divalent manganese has been investigated in the crystals GdF_3, $KMgF_3$, and $CdTe$, which have cubic symmetry, and in the crystals ZnO, $MgCl_2$, and $CdCl_2$, which have axial symmetry. The measured cubic field splitting parameter a is compared with values predicted from recent theoretical work.

The lifetime of the 638 kev level in ^{131}Xe. By W. D. Hamilton.

A nuclear resonant scattering method was used to estimate the lifetime of the 638 kev level in ^{131}Xe. The result of 4×10^{-12} sec, when compared with the Weisskopf estimate is consistent with an enhanced E2 transition or a retarded M1 transition. However, in reported Coulomb excitation experiments there is no evidence for an E2 transition probability consistent with the present lifetime, and it is suggested that the transition may be predominantly M1.

The effect of particle streams on transverse hydromagnetic waves. By E. R. Harrison.

A magnetic field is 'frozen' into a moving conducting fluid when certain conditions are fulfilled, as for example, when the frequency of the fluid disturbance is small compared with the cyclotron frequencies of the fluid particles. If the fluid contains streams of moving particles parallel to the magnetic field, the magnetic field is also 'frozen' into the streams when there are transverse perturbations. The condition now is that the Doppler shifted frequency of the disturbance must be small compared with the cyclotron frequency of the stream particles. It follows that the phase velocity of transverse hydromagnetic waves is modified if such streams are present. In effect, the momentum flux of the streams reduces the 'tension' of the magnetic flux times. Where the kinetic energy density relative to the centre-of-mass system exceeds the magnetic energy density, the phase velocity in an infinite medium has complex conjugate values and the hydromagnetic wave grown in amplitude. In the case of a stream of finite radius the phase velocity shows dispersion for wavelengths comparable with or greater than the stream radius and there is an increase in the domain of stability.

Calculated electron mobility in nitrogen, oxygen and air for $0 \cdot 1 \leqslant E/p \leqslant 100$ v cm^{-1} manifg^{-1}. By A. E. D. Heylen.

The influence of different electron energy distribution functions, whose mean energy is obtained from swarm experiment data, and of various collision cross section variations upon the calculated mobility is investigated. It is shown that the mobility is mainly determined by the total scattering cross section and is insensitive to the form of the distribution, provided the cross section does not vary too rapidly with electron energy. Calculations are carried out assuming the Maxwellian distribution to hold and, using representations close to the experimental cross section data, good agreement between calculated and experimental mobility is obtained for some but not all of the available data.

Measurements of quenching of ortho-positronium in gases. By F. F. Heymann, P. E. Osmon, J. J. Veit and W. F. Williams.

Three photon annihilations of ortho–positronium in gases as a function of pressure have been investigated using a scintillation spectrometer technique. Quenching rates per atmosphere were determined for argon ($0 \cdot 035\lambda_0$), neon ($0 \cdot 024\lambda_0$), helium ($0 \cdot 014\lambda_0$), oxygen ($3\lambda_0$), nitric oxide ($400\lambda_0$), and carbon dioxide ($0 \cdot 08\lambda_0$), the last three being only very approximate. λ_0 is the natural annihilation rate of ortho-positronium, $0 \cdot 7 \times 10^7$ sec.$^{-1}$ The high quenching rates in oxygen and nitric oxide are attributed to ortho-to-para conversion by electron exchange. The order of magnitude of the smaller quenching rates is understandable if the positronium atom annihilates with an electron of a gas molecule during collision (pick-off quenching).

Gamma-ray angular correlation in the inelastic scattering of medium energy protons from the first excited state of ^{12}C. By G. L. Salmon, A. B. Clegg, K. J. Foley, P. S. Fisher, and D. J. Rowe.

Measurements are reported of the polarization of the first excited state of ^{12}C produced by inelastic scattering of 150 MEV protons through several angles, the polarization being indicated by the angular correlation of the decay gamma-rays. The results are analysed to obtain information about the details of the inelastic scattering interaction. In particular they show that much the same nuclear wave functions are involved in this medium-energy proton reaction as in low-energy reactions.

Growth and decay of luminescence intensity under cathode ray excitation. By M. Sayer.

Expressions for the growth and decay of cathodoluminescence intensity are derived for phosphors which show exponential decay schemes under ultra-violet excitation. A model is used in which excitation of luminescence centres can take place either by direct interaction with primary electrons or indirectly by transfer of energy from excited lattice electrons. Two systems are considered: (*a*) with monomolecular recombination in the lattice and monomolecular recombination in the centres, (*b*) with bimolecular recombination in the lattice and monomolecular recombination in the centres. Comparison between the theory and published experimental data indicates that such a model with bimolecular recombination in the lattice is compatable with many of the available experimental results.

Synthesis of interference filters. By J. S. Seeley.

A method of synthesizing electrical circuit filters to transmit prescribed functions of frequency in a specified pass-band is applied to dielectric interference filters containing up to four half-wave layers. The method relies on an approximation that the half-wave layers are the only parts of the filter which are sensitive to frequency. The reflecting quarter-wave multilayers are described by a single parameter whose values are deduced in the synthesis. The transmission functions are either maximally-flat in the pass-band or contain equal ripples. The rate of transition from the pass- to the stop-bands is increased rapidly by increasing the number of half-wave layers.

The synthesis is applied to filters specified to transmit an 8% bandwidth within which the transmissivity is not less than 0·91. The exact transmission characteristics of these examples show excellent agreement in the pass-band with the simple functions.

The method can be applied to the design of filters of moderate bandwidth for any spectral region.

The rise-time of pre-breakdown current pulses in nitrogen and air. By D. J. Tedford and D. T. A. Blair.

Observations on the growth of the current pulses of electron avalanches in nitrogen, dry air and humid air, for pd values in the range 100 to 2300 mm Hg cm, are reported. A possible explanation for the delayed rise-time of the pulses in nitrogen and dry air is suggested.

Some electrical and optical properties of InAs–In_2Se_3 and InSb–In_2Se_3 alloys. By J. C. Woolley and P. N. Keating.

Polycrystalline specimens of InAs–In_2Se_3 and InSb–In_2Se_3 alloys have been prepared by suitable annealing of ingots. Measurements have been made of the room temperature values of Hall effect, conductivity, thermoelectric power and infra-red absorption over the whole of the available range of solid solution, and hence values of carrier density n, mobility μ and optical energy gap E_g determined. It is found that the behaviour is similar to that of the corresponding In_2Te_3 alloys in that the alloys rich in A^{III} B^V are n-type and highly degenerate. The observed values of n for the four systems concerned (A^{III} B^V–$A_2{}^{III}B_3{}^{VI}$) are compared, and possible explanations of the results in terms of solubility of tellurium and selenium in the A^{III} B^V compounds, or the band structure of the A^{III} B^V compounds are discussed. The use of thermoelectric power data to give values of the Fermi level is considered, and it is shown that to give consistent results in the composition range where ionized impurity scattering occurs a scattering relation of the form $\tau \propto E^{+1/2}$ must be used. The results suggest that the InAs–In_2Se_3 system may show a change in conduction band minimum at a composition of low In_2Se_3 content.

Vacancy induced ordering in Cu_3Au. By P. Wright and J. C. Goodchild.

A two-stage quenching process by which a specimen can be quenched from a temperature well above the critical temperature for long-range ordering to liquid air temperature has been designed. Provision is made for subsequent rapid transfer of the specimen to and from the liquid air bath to an annealing bath.

By these means the isothermal ordering of quenched Cu_3Au wires has been investigated, using the resistivity of the wire as an indicator of the state of order, at various temperatures of anneal down to 30°c.

Even at quench rates of 60 000 deg sec^{-1} appreciable ordering occurs during the quench, and the short-range ordering stage is not completely preserved for observation during the subsequent anneal. The activation energy for migration of quenched-in defects appears to increase with degree of long-range order. The principal mobile defects are single vacancies and they have a migration energy of 1·0 ev in Cu_3Au in the early stages of long-range ordering.

Isothermal ordering at 100°c is found to increase with pre-quench temperature up to ≃650°c and then decrease. Trivacancies in high concentration are considered as a factor contributing to the anomalous decrease.

On the application of two simple approaches of 'Atoms in molecules'. By Alicia Batana and Norah V. Cohan.

Two simple approaches of the method of 'atoms in molecules' developed by Moffitt and Hurley have been applied to the lowest $^1\Sigma_u{}^+$ state of the hydrogen molecule. A trial wave function made up from a linear combination of a covalent ($1s\ 2p_\sigma$) and an ionic structure ($1s^2$) was used. The effect of different procedures used for selecting orbital exponents and mixing coefficient of covalent and ionic functions was studied and, in particular, the risk of using a minimization procedure was considered.

The spin–orbit coupling of a 4p electron in Cu III. By C. A. Bates.

Estimates of the spin-orbit coupling parameter, ζ_{4p}, in Cu III are made from an analysis of the energies of the multiplets derived from the $3d^9(^2G)4p$ configuration which were tabulated by Moore in 1952. The lowest term Z^1D^o in the configuration is also examined and the value for ζ_{4p} is concluded to be 925 ± 40 cm^{-1}.

LETTERS TO THE EDITOR

Antiferromagnetic resonance in the extreme infra-red. By D. Bloor and D. H. Martin.

The skeletal modes of long-chain molecules. By S. B. Field and D. H. Martin.

The electronic specific heat of scandium and yttrium. By H. Montgomery and G. P. Pells.

Plasma drift velocity across a confining magnetic field. By S. Miyajima, S. Ito and P. C. Thonemann.

Sub-lattice magnetic moments in manganese ferrite. By W. P. Osmond.

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SYMPOSIUM

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COURSES

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